

PROCEEDINGS  
OF THE  
ENGINEERING SUMMER SCHOOL (SOUTHERN REGION)  
21ST JUNE TO 9TH JULY 1965

SPONSORED BY  
THE ASSOCIATION OF PRINCIPALS OF TECHNICAL INSTITUTIONS  
(INDIA)  
IN COLLABORATION WITH  
THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

COLLEGE OF ENGINEERING, GUINDY  
MADRAS 25

## CO-ORDINATORS:

## AMERICAN

J. C. LEACH

PROFESSOR

FACULTY OF MECHANICAL  
ENGINEERING

UNIVERSITY OF ILLINOIS

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ILLINOIS, U.S.A.

## INDIAN

T. MUTHIAN

DIRECTOR OF TECHNICAL EDUCATION

MADRAS

## CO-COORDINATOR

V. KALYANARAMAN

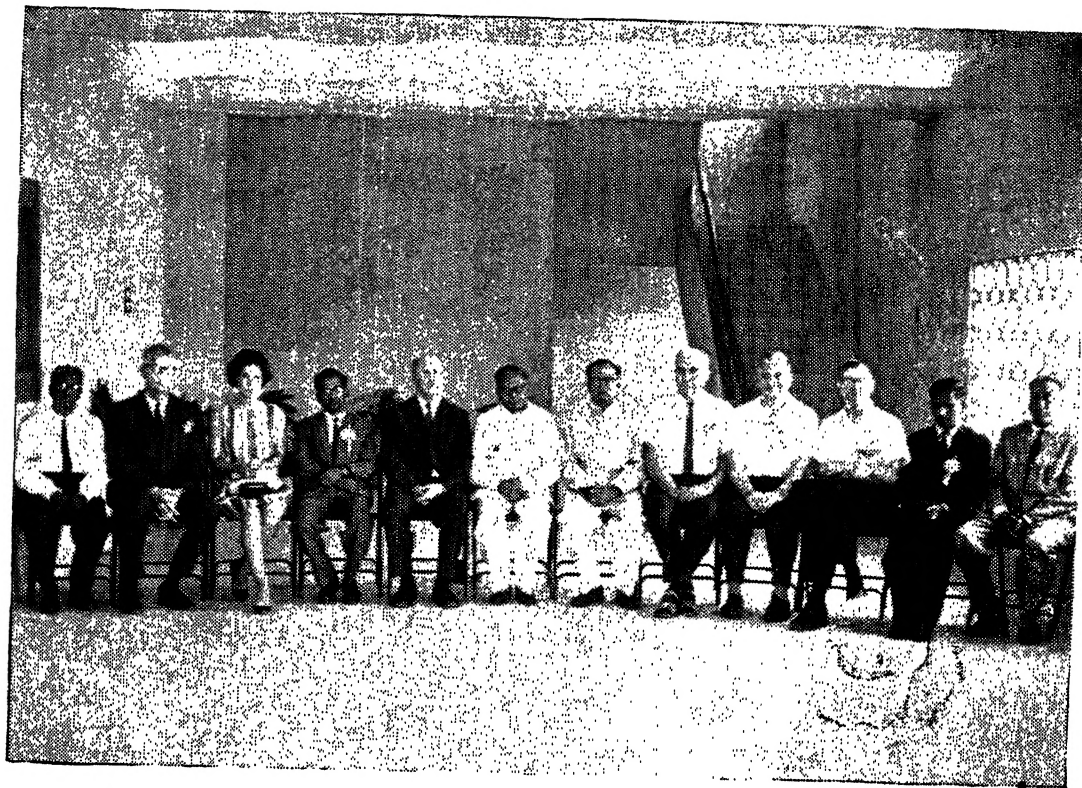
PRINCIPAL

COLLEGE OF ENGINEERING

GUINDY

MADRAS





THE HONOURABLE MINISTER WITH THE CO-ORDINATORS,  
AMERICAN EXPERTS AND THE INDIAN COUNTER PARTS

*L. to R.* Mr. Balakrishnan Nair, Prof. J. R. Martin, Mrs. Leach, Prof. A. P. Jambulingam, Prof. J. C. Leach, The Hon. Minister Sri R. Venkataraman, Prof. V. Kalyanaraman, Prof. L. V. Nothstine, Prof. I. O. Ebert, Prof. W. J. Feireisen, Prof. V. C. Kulandaiswamy and Prof. S. Srinivasan.

RESOURCE PEOPLE:

CIVIL ENGINEERING:

AMERICAN CONSULTANT : LEO V. NOTHSTINE  
INDIAN COUNTERPART : V.C. KULANDAI SWAMY

MECHANICAL ENGINEERING:

AMERICAN CONSULTANT : W.J. FEINLISEN  
INDIAN COUNTERPART : A.P. JAMBULINGAM

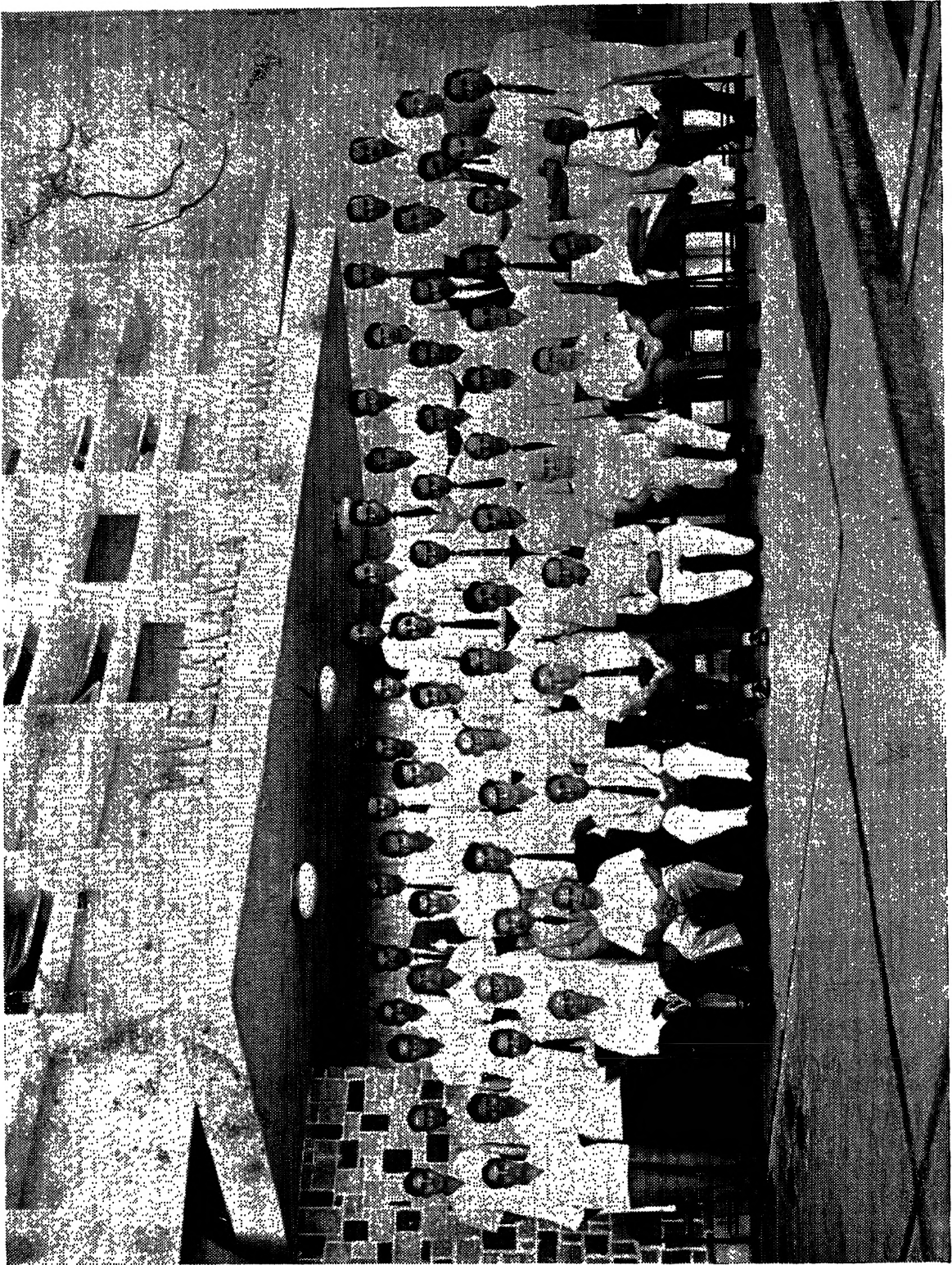
ELECTRICAL ENGINEERING:

AMERICAN CONSULTANT : I.O. EBERT  
INDIAN COUNTERPART : S. SRINIVASAN

## LIST OF PARTICIPANTS

## CIVIL ENGINEERING:

1. G.T. AZARIAH THANASINGH  
Assistant Professor  
A.C. College of Engineering &  
Technology  
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2. P. L. MELIYAPPAN  
Professor  
Thiagarajar College of  
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Madurai
3. Y. ANANTANARAYANA  
Assistant Professor  
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Coimbatore
4. S. NARAYANASWAMY  
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5. D. JEEBATA RAO  
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6. H.S. SHIVASWAMY  
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7. M.S. JAYADEVA  
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8. D.V. GANGADHAR  
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9. S.T. NAGARAJA  
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10. A. KULATHU IYER  
Reader  
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11. V.N. VAPPICHA  
Assistant Professor  
Engineering College  
Trichur (Kerala)
12. T.C. GEORGE  
Principal & Professor  
Engineering College  
Trichur (Kerala)
13. K.M. BAHAUDDIN  
Professor  
Regional Engineering College  
Calicut (Kerala)
14. R. BHIMASEN RAO  
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16. S.R. SRINIVASAN  
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17. P. PURUSHOTHAMAN  
Assistant Professor  
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18. C.T. SRIRAMULU  
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19. M. NALLUSWAMY  
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2. K. KAMARAJAN  
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Madurai
3. K. ARUMUGAM  
Lecturer  
P.S.G. College of Technology  
Coimbatore
4. Md. SULAIMAN  
Professor  
Government College of  
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Coimbatore
5. T.B. PARTHASARATHY  
Assistant Professor  
College of Engineering  
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6. S. NARAYANA BHAT  
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7. S. RAMA GOWDA  
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8. T.S. JAYADEVAIAH  
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9. S. NARAYANA IYER  
Reader  
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10. ABDUL KHADIR  
Assistant Professor  
Engineering College  
Trichur (Kerala State)
11. P. SUBRAMANIAN  
Lecturer  
S.V. University College of Engg.  
Tirupathi (A.P.)
12. P.V.V.S. Sastry  
Professor  
M.I.T. Chromepet  
Madras-44
13. S. SELLARATNAM  
Lecturer  
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Madras-25
14. V.N. SUJEER  
Assistant Professor  
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Guindy, Madras - 25

15. P.C. CHANDRASIKHARAN  
Assistant Professor  
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16. V. KRISHNAMURTHY  
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Guindy, Madras - 25
17. P.M. RAMANATHAN  
Lecturer  
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18. D.K. NAMBUDRIPAD  
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College of Engineering  
Guindy, Madras-25
19. K.S. BIKSHANDEESWARAN  
Professor  
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Guindy, Madras-25
20. N.M. JANARDHAN  
Assistant Professor  
College of Engineering  
Guindy, Madras - 25



## MECHANICAL ENGINEERING

1. C. KOTHANDARAMAN  
Assistant Professor  
Thiagarajar College of  
Engineering  
Madurai
2. S. SUBRAMANIYAN  
Lecturer  
P.S.G. College of Technology  
Coimbatore
3. A.S. RAJU  
Lecturer  
Government College of  
Technology  
Coimbatore
4. U. SRIDHARA RAO  
Assistant Professor  
College of Engineering  
Kakinada (A.P.)
5. N. GOWRI SHANKAR  
Assistant Professor  
College of Engineering  
Anantapur (A.P.)
6. B. RAMESH PAI  
Reader  
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7. B.V. KRISHNAMURTHY  
Lecturer & Head of Department  
Sri Jayachamarajendra  
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8. K. SANKARAN  
Assistant Professor  
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9. M.P. MATHEW  
P.G. Professor  
Engineering College  
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10. M.N. NARAYANA RAO  
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Chromepet, Madras-44
11. S. VEDAIYAN  
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12. G.S.S. SHARMA  
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Madras Institute of Technology  
Chromepet, Madras-44
13. S. NARASIMHAN  
Assistant Professor  
Madras Institute of Technology  
Chromepet, Madras-44
14. R.P. ARTHUR  
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15. R. SAMUEL  
Assistant Professor  
College of Engineering  
Guindy, Madras-25
16. V. MAHALINGAM  
Lecturer  
College of Engineering  
Guindy, Madras-25
17. V.J.B. ALBUQUERQUE  
Associate Lecturer  
College of Engineering  
Guindy, Madras-25.

## PROGRAMME - FORENOON SESSION

- MONDAY      June 21    Registration of Participants
- Inauguration : R.VLNKATARAMAN  
Minister for  
Industries  
Govt. of Madras
- Speaker        : J.R. MARTIN  
University of Houston  
U.S.A.
- TUESDAY     June 22    Subject        : Objectives of Engineering  
Education
- Chairman      : LEO V. NOTHSTINE  
Professor of Civil Engg.  
Michigan State University  
U.S.A.
- Speaker       : S. RAJARAMAN  
Director of Technical  
Education  
Kerala
- WEDNESDAY   June 23    Subject        : Principles of Teaching  
and Learning as Applied  
to Engineering Education
- Chairman      : V. KALYANARAMAN        :  
Principal  
College of Engineering  
Guindy, Madras.
- Speakers     : 1. K.C. CHACKO  
Principal  
College of Engineering  
Trivandrum
2. J.D. SMITH  
Regional Representative  
British Council,  
Madras.



TUESDAY June 29 Subject : Humanities in Engineering Education

Chairman: I.O. EBLERT  
Professor in Electrical Engineering  
Michigan State University  
U.S.A.

Speakers: 1. R. KRISHNAMURTHY  
Head of the Department of English  
I.I.T. Madras.

2. D.N. NUTTALL  
Head of the Department of Humanities,  
I.I.T., Delhi.

WEDNESDAY June 30 Subject : Curriculum Objectives in Relation to Laboratories

Chairman: W.J. FEIRLISEN  
Professor of Mechanical Engineering  
Wisconsin University  
U.S.A.

Speaker : V. KALYANARAMAN

THURSDAY July 1 Subject : Preparation of Laboratory Experiments :

Chairman: LEO V. NOTHSTINE

Speakers: 1. T.S. VENKATARAMANAN  
Professor in Structural Engineering  
College of Engineering  
Guindy, Madras

2. K. ACHUTHAN NAIR  
Professor in Mechanical Engineering  
Government College of Technology  
Coimbatore.

- FRIDAY      July 2      Subject : Methods and Techniques in  
Engineering Instruction
- Speakers: 1. LEO V. NOTHSTINE  
2. W.J. FEIREISEN  
3. I.O. EBERT
- MONDAY      July 5      Subject : Role of Examinations
- Chairman: T.R. DAS  
Director of Technical  
Education  
Andhra Pradesh
- Speaker : C.P. RAMASWAMI IYER  
Vice- Chancellor  
Annamalai University
- TUESDAY      July 6      Subject : Computer Technology
- Speakers: 1. C.V. ANANDA RAO  
Asst. Professor of  
Electrical Engineering  
College of Engineering  
Guindy.
2. P. PURUSHOTHAMAN  
Asst. Professor of  
Structural Engineering  
College of Engineering  
Guindy
- Subject : Development and Growth of  
Instructors
- Chairman: T.R. DAS
- Speaker : LEO V. NOTHSTINE

WEDNESDAY July 7 Subject : Trends in the field of  
Engineering Education

Chairman: LEO V. NOTHSTINE

Speakers: 1. V.V.L. RAO  
Principal  
Regional Engineering  
College, Warangal  
Andhra Pradesh  
2. B. SENGUPTO  
Director  
Indian Institute of  
Technology  
Madras

THURSDAY July 8 Subject : Evaluation of Teacher and  
Teaching

Chairman: V.V.L. RAO

Speakers: 1. LEO V. NOTHSTINE  
2. W.J. FAIRFELDEN  
3. I.O. EBBERT

Subject : Examinations and Internal  
Assessment of Students in  
Engineering Colleges

Chairman: LEO V. NOTHSTINE

Speaker : T. MUTHIAN  
Director of Technical  
Education  
Madras

FRIDAY July 9 Subject : Evaluation of Summer  
School

Chairman: V. KALYANARAMAN

Speaker : I.O. EBBERT

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## PROGRAMME - AFTERNOON SESSION

## CIVIL ENGINEERING GROUP:

- MONDAY June 21 INTRODUCTION - Filling out forms,  
Orientation and Familiarisation,  
Preparation of Roster
- TUESDAY June 22 Subject : Curriculum Review - U.S.A.-  
India  
Speaker : LEO V. NOTHSTINE
- WEDNESDAY June 23 Chairman: V.C. KULANDAISWAMY  
Subject : Formal and Informal  
Lectures, Planning and  
Presentation  
Speaker : H.S. SHIVASWAMY  
Professor in Civil  
Engineering  
Manipal Engineering College  
Manipal, Mysore.  
Subject : Place of Tutorials in Civil  
Engineering Instruction  
Speaker : P.L. MEIYAPPAN  
Professor in Civil Engineering,  
Thiagarajar College of  
Engineering  
Madurai (Madras)
- THURSDAY June 24 Chairman: LEO V. NOTHSTINE  
Subject : Objectives of Laboratory  
work  
Speaker : K.M. BAHAUDDIN  
Professor in Civil Engg.  
Regional Engineering  
College  
Calicut (Kerala).



Subject : Planning Laboratory Exercises  
for a course in Strength of  
Materials, Hydraulics and  
Survey.

Speakers: 1. P. PURUSHOTHAMAN

2. S. NARAYANASWAMY  
Asst. Professor in Civil  
Engineering  
Govt. College of Technology  
Coimbatore (Madras)

3. D. JEEBALA RAO  
Professor in Civil Engg.  
College of Engineering  
Makinada (Andhra Pradesh)

FRIDAY      June 25    DEMONSTRATION:  
Use of Visual Aids in Civil  
Engineering Instruction -  
Slides on Prestressed  
Concrete - Models on Shell  
Structures.

MONDAY      June 28    Film      : Basic Fluid Mechanics

TUESDAY      June 29    Chairman: R. BHIMASEN RAO  
Professor in Civil Engg.  
B.V. Bhoomareddi College  
of Engineering & Technology  
Hubli, (Mysore)

Subject : The Objectives of Project  
Method and its use in Civil  
Engineering instruction.

Speakers: 1. V.N. VAPPICHA  
Asst. Professor in Civil  
Engineering  
Engineering College,  
Trichur (Kerala)

2. M.S. JAYADEVA  
Reader in Civil Engg.  
Sri Jayachamarajendra  
College of Engineering  
(MYSORE)

3. D.V. GANGADHAR  
Lecturer in Civil Engg.  
R.V. College of Engg.  
Jayanagar, Bangalore  
(MYSORE)

WEDNESDAY June 30 Subject : Computer Programming

THURSDAY July 1 Subject : Computer Programming

FRIDAY July 2 Film : Nuclear Power

MONDAY July 5 Chairman: LEO V. NOTHSTINE

Subject : Seminar Method in Civil Engineering instruction

Speaker : A. KULATHU IYER  
Reader in Civil Engineering  
Engineering College,  
Trivandrum (KERALA)

Subject : Curriculum Planning for a Civil Engineering Degree Course

Speaker : K.M. BAHAUDDIN

TUESDAY July 6 Chairman: H.S. SHIVASWAMY

Subject : Techniques of Design of Examinations

Speaker : LEO V. NOTHSTINE

WEDNESDAY July 7 Subject : Productivity in Engineering Education

Speaker : R. SAMUEL  
Asst. Professor in Mechanical Engineering,  
College of Engg., Guindy.

THURSDAY July 8 Chairman: K.M. BAHAUDDIN

Subject : Careers in Civil Engg. - Teaching - Opportunities and Limitations

Speaker : D. JILBALA RAO

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## PROGRAMME - AFTERNOON SESSION

## ELECTRICAL ENGINEERING GROUP:

- MONDAY June 21 INTRODUCTION of participants  
Introductory remarks by I.O. EBERT  
Professor of Electrical Engineering  
Michigan State University,  
and  
S. SRINIVASAN  
Professor of Electrical Engineering  
College of Engineering, Guindy,  
Madras - 25
- TUESDAY June 22 Subject : Semiconductor Electronics I  
Speaker : I.O. EBERT  
Film : Magnetic Materials
- WEDNESDAY June 23 Subject : Semiconductor Electronics II  
Speaker : I.O. EBERT  
Film : Transistors
- THURSDAY June 24 Subject : Semiconductor Electronics III  
Speaker : I.O. EBERT  
Film : Zone Melting
- FRIDAY June 25 Chairman: S. SRINIVASAN  
Subject : Engineering Curriculum and  
Course work in USA and India  
- A comparative assessment.  
Speakers: I.O. EBERT and some of the  
participants.  
Film : Ferromagnetic materials  
and Hysteresis, and  
Atomic Power at Shipping  
Stations.

- MONDAY June 28 Chairman: I.O. EBERT  
 Subject : System Stability in the sense of Lyapunov  
 Speaker : P.C. CHANDRASEKHARAN  
 Asst. Professor of  
 Electrical Engineering  
 College of Engineering  
 Guindy, Madras-25
- TUESDAY June 29 Chairman: S. SRINIVASAN  
 Subject : Principles and Applications of Linear Motor  
 Speaker : K.M.A. Md. SULAIMAN  
 Professor  
 Govt. College of Technology  
 Coimbatore  
 Chairman I.O. EBERT  
 Subject : An introduction to the Principles and Applications of Superconductivity.  
 Speaker : K. VEENKATASUBRAMANIAN  
 Asst. Professor  
 A.C. College of Engineering and Technology  
 Karaikudi
- WEDNESDAY June 30 Subject : Computer Programming
- THURSDAY July 1 Subject : Computer Programming
- FRIDAY July 2 Film : Nuclear Power
- MONDAY July 5 Chairman: S. SRINIVASAN  
 Subject : Digital Studies of Power Systems Load Flow Study  
 Speaker : V.M. SUJEE  
 Asst. Professor  
 College of Engineering  
 Guindy, Madras-25.

TUESDAY      July    6    Chairman: I.O. IFFERT  
Subject : Digital Studies of Power  
          Systems - Short Circuit  
          Study.  
Speaker : V.N. SUJIER  
          Asst. Professor  
          College of Engineering  
          Guindy, Madras-25

WEDNESDAY    July    7    Subject : Productivity in Engineering  
                                 Education  
Speaker : R. SAMUEL  
          Asst. Professor of Mech.  
          Engineering,  
          Guindy, Madras-25

THURSDAY     July    8    Chairman: I.O. EBERT  
Subject : Education and Training of  
          a Modern Engineering  
          Student.  
Speaker : S. SRINIVASAN  
          Professor of Electrical  
          Engineering  
          College of Engineering  
          Guindy, Madras-25

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## PROGRAMME - AFTERNOON SESSION

## MECHANICAL ENGINEERING GROUP:

- MONDAY June 21 INTRODUCTION, Objectives of Summer School.  
Slides of University of Wisconsin Campus, Madison, U.S.A.
- TUESDAY June 22 Subject : Mechanical Engineering Curriculum  
Speaker : W.J. FEIREISEN  
Film : Schliesen  
Approaching the speed of sound.
- WEDNESDAY June 23 Subject : Teaching the Thermosciences  
Speakers: A.P. JAMBULINGAM  
W.J. FEIREISEN  
Film : Flow Visualization  
Pressure Fields and Fluid Acceleration
- THURSDAY June 24 Subject : Teaching of Machine Design  
Speaker : R. SAMUEL  
Film : Structural Testing
- FRIDAY June 25 Subject : Industrial Engineering and Manufacturing Processes  
Speaker : H.O.N. JOSEPH  
Film : Modern Steel Making  
Chemistry of Iron and Steel
- MONDAY June 28 Film : The Fluid Dynamics of Drag (4 parts) with introduction by W.J. FEIREISEN

- TUESDAY June 29 Subject : The Role of the Shop and  
Co-operative Programme in  
Mechanical Engineering  
Curricula  
Speaker : R.P. ARTHUR  
Film : Steel Processing
- WEDNESDAY June 30 Subject : Computer Programming
- THURSDAY July 1 Subject : Computer Programming
- FRIDAY July 2 Film : Nuclear Power Engineering
- MONDAY July 5 Subject : The Mechanical Engineering  
Laboratory: Its place in  
the curriculum.  
Speaker : W.J. FEIREISEN  
Film : Increasing the Efficiency  
of Development Testing  
(2 parts)
- TUESDAY July 6 Subject : Mechanical Engineering  
Laboratory:  
Developments of experiments  
Speaker : W.J. FEIREISEN  
Film : Tomato in a Box  
21st Century Power
- WEDNESDAY July 7 Subject : Productivity in Engineering  
Education  
Speaker : R. SAMUEL  
Film : New Power for Flight  
La Flur Cryorganic  
Systems
- THURSDAY July 8 Subject : Professional Communication,  
Report Writing  
Speaker : W.J. FEIREISEN  
Film : Project Apollo; Manned  
Flit to the Moon"  
F-1 The Mighteed Rocket  
Engine  
Electric Propulsion.

## PROGRAMME - SPECIAL LECTURES

THURSDAY June 24 Chairman: V. KALYANARAMAN

Subject : Monoliths

Speaker : P.S. SUBRAMANIAM  
Executive Director  
Gannon Dunkerley Ltd.  
Madras.

MONDAY      June 28    Chairman: LEO V. NOTHSTINE

Subject : Role of Engineers in Plan Projects.

Speaker : M. GANAPATHY  
Retired Chief Engineer  
Kandla Project.

TUESDAY June 29 Chairman: I.O. EBERT.

Subject : A City's Water Supply with  
Special Reference to  
Problems of Madras City.

Speaker : O.T. RAGHAVAN  
Water-works Engineer  
Corporation of Madras.

TUESDAY July 6 Chairman: S. SRINIVASAN

Subjects: High Rupturing Capacity  
Cartridge Fuse Links.

Speaker : C.R. BALASUBRAMANIAM  
Senior Engineer  
English Electric Co. of  
India Ltd., Madras.



PROGRAMME - VISITS

SATURDAY	June 26		Visit to Integral Coach Factory, Madras.
SUNDAY	June 27		Visit to Mahabalipuram
SATURDAY	July 3	X X X X	Visit to Neyveli Lignite Corporation works at Neyveli.
SUNDAY	July 4	X	



**SRI R. VENKATARAMAN**  
Minister for Industries and Technical Education, Govt. of Madras,  
Inaugurating the Summer School.



**PROF. J. R. MARTIN**

**University of Houston, U. S. A.**

**Speaking to the Participants on "Engineering Education in A Developing National Economy".**



PROF. J. C. LEACH  
American Co-ordinator for the Engineering Summer Schools in India,  
Addressing the Participants.

WELCOME ADDRESS BY SRI T.MUTHIAN\*, DIRECTOR OF TECHNICAL EDUCATION AND COORDINATOR, ENGINEERING SUMMER SCHOOL (SOUTHERN REGION), MADRAS.

Honourable Minister, Learned Professors, Participants of the Summer School, Ladies and Gentlemen,

I have very great pleasure in extending a hearty welcome to you all on this happy occasion of the inauguration of the Summer School for Teachers in Engineering Colleges in the Southern Region, which is being conducted here in the Engineering College Campus for a period of three weeks from to-day (21-6-1965). We are particularly grateful to our Hon'ble Minister for Technical Education, who, in spite of the heavy call on his valuable time, has so kindly agreed to inaugurate the Summer School here this morning. The great personal interest which he has in the progress and development of Technical Education in this State is too well known and his presence here today is in itself a proof of that interest.

The Summer Schools for Teachers in Technical Institutions in this country are organised on a regional basis by the Association of Principals of Technical Institutions (India) in collaboration with the USAID, New Delhi. The tremendous expansion of Technical Education in India during the past decade has confronted

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\*The address was read by Prof. V. Kalyanaraman since Sri T. Muthian was on a tour of U. S. A.

all institutions with the serious problem of the shortage of qualified teachers. In addition, the boundaries of knowledge during recent years, have moved forward so rapidly, particularly in the field of Engineering and Technology that curricula and courses have not kept pace with the rapid increase in scientific knowledge. It is needless to mention that it is of utmost importance that teachers in Technical Institutions in the country should become familiar with the latest developments in content, methods and techniques, so that the teaching undertaken by them adequately reflects the progress made. The Summer School Programmes have, therefore, been organised by the Association of Principals of Technical Institutions (India) to provide teachers in Engineering Colleges and Polytechnics with the opportunity of making a concerted and combined effort to acquire a greater appreciation of the exact place of Engineering Education in India's total educational spectrum, and to reorient the curricula and methods and techniques of teaching. Broadly speaking, the following are the main objectives of the Summer School:

- i) to introduce the best teaching methods and techniques for the various disciplines,
- ii) to improve the subject matter competence of the participating teachers,
- iii) to ~~introduce their skills as teachers~~ and their ability to inspire students.

- iv) to stimulate the interest of teachers by bringing them in contact with prominent men in their field of teaching,
- v) to relate Engineering Education to the needs of Indian Industry,
- vi) to provide the opportunity to selected individuals to acquire the skills and knowledges related to the operation of Summer School Programmes, and
- vii) to provide the time, means and encouragement for discussion amongst the participant - teachers with similar backgrounds, interests and problems so as to create greater mutual understanding and appreciation of each other's problems.

The Summer Schools will thus provide a significant opportunity for the participating teachers to find inspiration and stimulation of extended personal contact with other teachers in their respective fields as well as some eminent technical educators. Experienced Professors of Engineering disciplines from some of the American Universities are associated with the Summer School Programme as expert consultants to help organise and conduct the programme in an efficient manner and they are assisted by Indian Counterparts. I extend a special welcome to the American Professors who are here with us and I am sure that

with their great care and interest the Summer School which is being conducted here, will be an unqualified success.

The first Summer School for Engineering College Teachers in the Southern Region (States of Madras, Andhra Pradesh, Mysore and Kerala) sponsored by the A.P.T.I. (I) in collaboration with the USAID, was conducted last year (1964) at the P.S.G. College of Technology, Coimbatore. Encouraged by the response to and success of that school, the sponsors have expanded their programme and this year in addition to the normal programme, a Special Summer School for Engineering College Teachers is also being held in each region. While the normal programme for the Southern Region this year, is conducted here at the College of Engineering, Guindy, a special school programme is being conducted at the P.S.G. College of Technology, Coimbatore. A Summer School for Polytechnic teachers in the Southern region was conducted last year at the Central Polytechnic, Adyar, Madras, and this year also, a similar school is being conducted at the Central Polytechnic.

The normal Summer School programme is confined to the three main Engineering disciplines - Civil, Mechanical and Electrical- and the total number of participants for each region is limited to sixty. I am very happy to mention that the Summer School



for Teachers of Engineering Degree Courses which is being inaugurated today, has the full compliment of sixty participants representing the various Engineering Colleges and other Institutions conducting degree courses in Engineering in the four States of the Southern Region. I sincerely hope that all these participant teachers will take full advantage of this Summer School Course and derive the maximum benefit therefrom, so that they can, when they go back to their respective institutions on the completion of the course, make use of the extra knowledge and experience gained by them to improve the techniques and standards of teaching. I also hope that with the whole-hearted cooperation of all concerned, this Summer School will be a great success and that it will not only be hailed as a model to be emulated by others, but its success will also lead to such Summer School Programmes being conducted here-after as a regular feature; and possibly on a wider and more expanded basis. I wish all the participants a pleasant and comfortable sojourn here and a really beneficial and worthwhile term of Summer School participation.

I once again extend a hearty welcome to all on behalf of the sponsors of the Summer School Programme and on my own behalf.

Thank you.

INAUGURAL ADDRESS BY SRI R.VENKATARAMAN, MINISTER FOR INDUSTRIES, GOVERNMENT OF MADRAS.

Sri R.VENKATARAMAN, Minister for Industries and Technical Education, Government of Madras, inaugurated the Summer School and an extract of his speech is given below:

There are at present eleven engineering and technological institutions in the State turning out annually about 1200 Engineers. Engineering Technology has now come to be realised as an important factor, necessary for accelerating the industrial development of our Country. The present degree course in engineering is fairly well balanced between the requirements of humanities, science and technology. But not enough emphasis has been given to teaching the practical side of the Profession. The students passing out of these courses do not have that practical background necessary to take up the type of design, planning and execution of works which the engineers are expected to do. Instruction has lacked close contact with practical life. In view of the vast strides in technical development being made in the country now and the likely step-up in the tempo of such activities in the future, it is very essential for an engineering student to be fully conversant with the potentialities of processes and skills connected with his profession and to have an

intimate knowledge of crafts which would enable him to give technical guidance to craftsman. Technical education should aim at training well educated and cultured citizens equipped with a knowledge of modern science and technology, capable of skilled work, physically fit and imbued with a spirit of patriotism. I hope that this Summer School during its three week deliberations would also examine the educational pattern and would be able to recommend a policy by which the aims of technical education could be truly achieved. I wish the school all success and have great pleasure in inaugurating it.

James L. Leach, the American Co-ordinator for the Summer Schools in India also made a brief speech. An extract of his speech is given below:

JAMES L. LEACH expressed his pleasure in being present on the occasion of the inauguration of the Summer School for the Southern Region and participating in the proceedings of the day. He said that he had the privilege of knowing many Indian students personally when they were studying in U.S.A. In their analytical ability and theoretical knowledge they are second to none. They are nearly as well equipped as their counterparts in advanced countries. But when it comes to application, they are somewhat diffident. There are various reasons for the prevalence of such a situation. It is necessary that the engineering teachers be aware of this fact and lay necessary emphasis on developing the ability to apply the knowledge acquired by the students.

He said that the future engineers of India have great opportunities and responsibilities. Taking for instance the field of communication alone, there is an enormous scope for progress and development. The same would be true of many other areas. The engineers' education and training should be such that they are well equipped not only to face the problems of today but also those of tomorrow.

He hoped that the deliberations of the Summer School would help the participants to understand, in proper perspective, some of their problems and seek solutions on the basis of co-operative effort. He felt that the contact brought about among the staff from various institutions would have a lasting effect. He wished the Summer School all success.

ENGINEERING EDUCATION IN A DEVELOPING NATIONAL ECONOMY  
J.R.MARTIN

Mr.Venkataraman, et al,

I am very pleased and greatly honoured to participate in the inauguration of this summer institute for teachers of engineering. It is most appropriate that it should begin by examining the purposes and objectives of engineering education. These are inextricably linked with those of the developing nation, for engineering is not an isolated function operating independently of other professions and crafts.

I would like to relate a story that you may recognize. Once there was a land and a people that was the colonial possession of one of the world's great powers. These people suffered all those restrictions associated with colonial administration. When they petitioned for redress of their grievances no satisfaction was obtained. They inevitably reached the conclusion that their true destiny lay in independence. Leaders among the people arose, men of strong character, great learning, sincerity and conviction. They had the gift of leadership and the belief that the future of their country was worth sacrificing their own interests for. After much strife and violence they finally obtained independence.

They then set about the work of governing themselves and building a nation. They wrote a constitution that established a democracy, provided for a bicameral system of legislation, a President, a Supreme Court, and, above all, guaranteed the fundamental rights of the people. The nation was to be a federation of self-governing states.

In its early days the nation was threatened by external powers that cast a covetous eye on its territory and resources. It was torn internally by dissenting political parties that opposed democracy. In spite of such obstacles the nation grew and prospered and took its place as the peer of any on earth. The belief in a people's ability to govern themselves and the freedom and dignity of the individual triumphed.

The name of this country is the United States of America. Perhaps you felt this story had a familiar sound to it, that perhaps I was describing India. So I was, for there are some remarkable parallels between the two. There are also many differences of course and one of these is that my country has had nearly 200 years since independence to develop. I predict that after a time much shorter than 200 years India will be a happier, prosperous country.

For India has made great strides in less than 20 years of independence. Although drastic change in

the life of the great mass of the people is not evident as yet, the statistics on production of steel and grain, reduction of disease, increase in life expectancy show that India is making great progress.

In the preambles of our two constitutions there are certain key words like 'justice' and 'liberty' that indicate similarity of purpose. Our Bill of Rights is in essence the same as Part III of your Constitution, 'Fundamental Rights'.

The Lok Sabha and the Rajya Sabha are similar to our House of Representatives and Senate.

The passion for freedom that gripped men like Thomas Paine and Patrick Henry is the passion that motivated Gandhi and Nehru. It is an universal passion that knows no political or cultural boundaries. We know that Gandhi was greatly influenced by the American philosopher Thoreau and his theory of Civil Disobedience. The incredibly erudite Mr. Nehru must have been influenced by his enviable knowledge of Western history and philosophy.

George Washington, the first president of the U.S. and the man usually referred to as the 'Father' of my country, was a surveyor in his early years. He maintained a plant for the manufacture of building brick on his estate in Virginia. The third President, Thomas Jefferson, was an architect, who also founded



the University of Virginia. The late President Herbert Hoover, great humanitarian and public servant, was also a Mining Engineer.

I cite these examples to show that engineers and builders are quite capable of national leadership, of making decisions of import to the nation. Such functions are not the exclusive prerogative of lawyers and politicians, doctors or priests.

It is axiomatic that the development of a great nation is dependent upon certain things. An adequate supply of energy is one. India has coal and hydro-electric power. The early development of the United States was dependent upon coal as its source of power. But oil and natural gas has now replaced many of the uses of coal. Hopefully India will discover sources of oil to power her developing economy. We read in the newspapers the discovery of geologic conditions favourable to oil production and it is certainly to be hoped that this wonderful resource will be discovered here where it is needed so badly. To develop this resource will require petroleum and chemical engineers, refinery and production technicians, and many varieties of trained workers and craftsmen. The discovery of substantial oil reserves in this country would terrifically accelerate its development.

Besides natural resources, a nation needs a healthy, educated, dedicated populace. The English philosopher John Locke said, "A sound mind in a sound body is a short but full description of a happy state in this world. He that has these two, has little more to wish for; and he that wants either of them, will be little the better for anything else".

And the British Prime Minister Benjamin Disraeli once said, "The health of the people is really the foundation upon which all their happiness and all their power as a nation depend". Health of the people is not the responsibility of the medical profession alone. The people's health depends on such things as pure and ample water supply, efficient and adequate sewage disposal systems, and these are the projects of engineers. A healthy population depends on an adequate, nourishing supply of food, and this is not solely an agricultural problem. Engineers are designers and builders of agricultural machinery, food processing machinery, and the equipment to distribute this food where needed. The preservation of food by canning requires the application of engineering knowledge and preservation of food by freezing is an untapped industry in this country.

To move people and goods a developing country needs better railroads and highways. A modern economy is based on being able to move great quantities of goods quickly and for long distances, something I have

found frustratingly difficult in moving the equipment I have brought to India.

A developing country needs a fast, efficient communications system. The rapid relay of news and information is essential to any modern economy. In the U.S. I can ring up a person in New York - 2000 miles away - by dialing him direct, without need of an operator, and be speaking with him in seconds. Contrast this with a call made to Delhi last week that took 4 hours. This kind of communication system is a deterrent to a highly developed economy.

These requisites for development are the work of engineers and it is the aim of engineering education to produce the engineers. Engineers are concerned with the physical world, the problems of design, construction and maintenance, the hard work of day-to-day living. Engineering educators must prepare their students to go forth into this kind of world, knowing what to expect and prepared to cope with it. The teacher cannot do a good job of this if he has not experienced it himself. He should take the initiative in finding out what goes on in the world outside his classroom. New engineering knowledge is not discovered by people who isolate themselves in ivory towers but by people who are willing to go to the world and try hundreds, even thousands, of solutions until they find the right one.

It is the obligation of the engineering educator to not only impart technical knowledge to his students but instill in him the high sense of purpose of engineering, what we may call engineering ethics. The student must be made to realize that the acquisition of an engineering education is a great privilege that carries corresponding responsibilities. Like the medical and legal professions, engineers are obliged to use their expert knowledge for the benefit of their employer, whether individual or corporation or governmental agency. Engineers can merit professional prestige only when they have demonstrated unquestioned honesty and high purpose to the people, gained their trust, and revered it as a sacred responsibility.

Engineering education should relate itself to the practical needs of the country. I have heard requests from Indian engineering teachers for courses in such subjects as pre-stressed concrete when the application of the knowledge of the water-cement ratio is not even used on the job; for courses in high speed electronic computers when ordinary desk calculators can hardly be found in engineering offices. I am not saying that engineers should not be interested in these high level topics but he is in danger of becoming so preoccupied with the upper fringes that he neglects to attend to the practical needs of his students and his country.

This country is not at that state of its development where it needs large numbers of people with science and research capabilities. It does need practical-minded people who can go out and apply technology that is already widely known, to build the roads, water supply, communications, distribution systems that the people so desperately needed. This is the direction that engineering education should take. We should first create the environment in which science and art can flourish. Neither law nor art can survive in a wasteland, they follow the trail of those who build.

Engineers and Engineering Teachers cannot ignore their responsibility for the social and economic consequences of their work. The public's trust should be regarded as sacred and engineers entrusted with operations financed by the people's money must see that the people are not cheated. Parents who entrust their children to our care for an education should be trained into technically competent and nobly motivated engineers. If I may take the liberty of quoting from your own BHAGAVADGITA, "For whatsoever a great man does, that very thing other men also do; whatever standard he sets up, the generality of men follow the same". It is up to the engineer's of the nation to set the example and it is up to you engineering educators to produce engineers with such capability.

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## "THE OBJECTIVES OF ENGINEERING EDUCATION"

S. RAJARAMAN

Friends,

I am very happy to be in your midst to-day, in my Alma Mater, to speak on a subject with which I have been closely associated for nearly three decades. I shall deal with the subject briefly and with special reference to Engineering Education at Collegiate and higher levels.

ENGINEERING EDUCATION: What is education?

"To educate is to develop (as a person) by fostering to varying degrees the growth or expansion of knowledge, wisdom, desirable qualities of mind and character, physical health, or general competence, especially by a course of formal study or instruction". In other words the three major functions of education are instruction, continuing education, and research. You all know the well-known definition of Engineering as the use of Science to fulfil the needs of man. It is, therefore, clear that the study of natural laws and the appreciation of the consequences flowing from them are matters of supreme importance and interest to the practising engineer. This knowledge has to be utilised to satisfy the material needs of man and having satisfied these needs, the engineer must help in developing a world community in which greater effort, time and

resources can be devoted to facilitating man's growth as a social, cultural and spiritual being. To quote from the American Society of Engineering Education's Committee on evaluation of Engineering education "The first objective, the technical goal of Engineering Education is preparation for the performance (or full knowledge) of the functions of analysis and creative design ..... The second objective, the broad social goal of Engineering Education includes the development of leadership ..... and the general education of the individual". Thus professional engineering education should fit a man for life and should, in addition, equip him for creativity in any position in his professional field.

When dams had to be put up, rivers to be bridged, Cities to be built, and factories to be constructed in large numbers, Civil Engineers were needed. Now when high speed and precision machines are to be manufactured, automobiles, supersonic jets and space crafts are to be produced, and gigantic steel plants are to be brought into being - all in large numbers, many Mechanical Engineers are required. The needs for control and automation, the tremendous rise in communication problems and the astounding scientific developments will call for more Electrical Engineers. Projecting a little further, one can predict a rise in the requirements of personnel with a good background of knowledge of Physics and Mathematics and even

biological sciences.

The rivers are spanned and the problem is how to deal with water pollution. Cities and factories are built and the problem is what to do about the slums and the fouled air. Better ways of killing people are found and the problem is to find ways of having peace. What we need, therefore, is not scientific research for pure knowledge) but engineering research (answer to questions arising out of needs of man), eg., food where improved methods of processing and storage and new means of manufacture are required; water where new sources from sea or weather have to be developed and pollution of existing sources reduced; air where pollution from industry and automobiles will have to be removed; waste disposal which has tremendous Engineering implications both for developed and developing nations; problems of communication and transportation, etc.

To sum up, the main objectives of Engineering education must be to provide the nation with designers, research technologists, constructors, production technologists, teachers and skilled craftsmen - all of quality. To achieve this objective, we will have to take stock of our present position and analyse the changes called for.



ENGINEERING DESIGN: While Engineering design frequently results in something tangible like a skyscraper, a speed reducer, or a transistor circuit, it is better to describe it as a mental process by which a need or objective is translated into a specific result. Engineering designs are made in a variety of ways-by empirical approach, mathematical analysis or by model studies. With the rapid Industrialisation of the country, the industries demand a large number of design engineers experienced in different fields. Developments that once required decades are now compressed into years. The Engineer is shaped more decisively at his formal training in the University than with all the influences the industries may exert later. Hence it has become essential that Engineering design is taught in the Universities in all the specialised fields. In the U.S.S.R., Engineering design is so well developed in the Universities that all major problems (e.g. all designs connected with space technology) are referred to them with necessary grants. The design and the connected research are always carried on by a team of experts and their design is taken up by the industries for execution.

Engineering design is the process of applying the various techniques and scientific principles for purposes of designing a system completely so as to permit its physical realisation. Hence the student of design at the commencement of his professional career will have to possess a background which will enable him to apply his knowledge in a responsible way. He thus becomes an intermediary between scientific knowledge and physical realisation. Thus the Universities at the highest level must aim to impart as much of sound scientific knowledge as possible.

The first stage in design training is the acquisition of knowledge and information pertaining to the basic disciplines. It is, therefore, necessary to provide a certain amount of design work in the curriculum. The emphasis should be more on the principles, methods of analysis, and basic properties of materials than on the factual details. The criterion of success will be the student's ability to think and persevere in his work within his own limitations. The best way to achieve this is by giving project work to the students and introducing electives in the final year.

During lectures, practical examples have to be taught in such a way as to develop a decision - making capacity in the student. He should be encouraged to

sketch out his ideas clearly as this is the only line of major communication between the designer and the draftsman. He should also develop the initiative to consider the alternative and choose the best compromise. This background can be efficiently covered by teaching the basic aspects of design for strength, rigidity, elastic stability, etc., in the early stages, then fundamental aesthetics, theories of proportions and industrial design, then tutorial sessions where originality is encouraged as much as time permits and finally end with a project work - each student being assigned a different work.

**RESEARCH:** Research is defined as 'an endeavour to discover facts by scientific study - course of critical investigation'. The driving force behind research is the man's unquestionable curiosity and his desire to seek rational explanation of natural phenomena. The necessity for research in the developing industries can be visualised by a comparison of the technological advancements of man with the need for further exploration in various fields viz., micro-miniaturization, remote control for harnessing dangerous elements, standards of quality in production, adaptation and response to environmental changes, reliability, compactness and precision, information theory and processing, etc. Modern technological disciplines

present such complex configurations that the research worker or experimenter has to resort invariably to the making of mathematical models of physical systems involved; formulation of the theories of measurements, instrumentation techniques, man-machine systems, etc. Another pertinent question facing a good scientist or engineer is whether he has been adequately trained in the fundamentals which would enable him to 'stay good'. The implementation and survival of the development programmes in any technological sphere (agricultural production, power and atomic or solar energy, communications and transport, space research, bio-electronic systems, etc.) depend upon the assimilation and utilisation of the techniques available to-day as well as on effecting further improvements in future. The scientists and engineers can achieve success in this field only if they are equipped with the essential tool - a good knowledge of the basic sciences.

An Engineer has naturally to be alert for improved methods and techniques which make use of natural resources and offer lower capital and operating costs, greater reliability or aesthetic advantages. He has also to solve new problems created by expanding technology and for the solution of which past methods may not be the sure guide. He has, therefore, to do research himself or take the help of a research worker, an institution or an Agency engaged in research work.

Research need not necessarily be done in laboratories. It can be done by him on plants which he is operating if he has keen observation and knows **how to interpret** results intelligently. Research may be 'pure' or 'applied'. Pure research is intended to add to our understanding of nature, while applied research is specially directed to a limited objective of immediate benefit to man.

Research and good teaching are collateral. A good teacher with research background possesses penetrating knowledge which is much in addition to that required for class room lecture. This gives him confidence and brings dynamism in the teaching. A penetrating teacher can induce the students to a high level of thinking. A teacher with good research contribution evokes respect from the students and adds prestige to the Institution.

Research should not be the prerogative of a few selected workers but its spirit and practice should inspire every member of the profession. The opportunities are greater to-day, than ever before, for the practising engineer to add something to the general store of knowledge. We will be judged by our successors not only by the engineering works produced in our generation but by our contribution to that body of knowledge which will provide them with the means to exceed our achievements.

As we cannot afford to gamble with matters affecting health, life and public money, we always want to make sure that our designs are safe and hence are slow in applying the results of research in new designs. Besides, engineering works have a long life and the results of research must ensure for the new construction equally long life and good performance with reduced operating costs.

Before taking up any problem for research, it is essential to find out what has already been done in that particular field or whether there is room for improvement in the methods by which the previous results were obtained. There must be sound thinking before a start is made because the art of research lies in the combination of basic thinking and practical experiment. For any scheme of research close-cooperation between the designer and the operating staff, practical applicability of the solution, and adaptability for design must be ensured.

To stimulate research activities in Engineering Institutions in India, the following suggestions are made:

- i) Freshly recruited staff to be kept temporary and confirmed only after they show marked self-development by research, preferably for attainment towards a higher degree.

- ii) A confirmed staff member should contribute at least one technical paper in a year.
- iii) Seminars should be arranged periodically when, in addition to the teaching staff, specialists from the Industry be requested to address and take part in the deliberations.
- iv) Incentives be established for research contribution. There should be more national recognition for meritorious work.
- v) Industries, defence establishment, etc., should sponsor research projects in technical Institutions.

DEVELOPMENT OF LABORATORIES: The objectives of laboratory work should be exemplify the various phenomena of nature and to develop a keen sense of scientific approach (art of measurement including accuracy, precision and errors, development of a degree of self-reliance and ingenuity and a chance to demonstrate resourcefulness, and acquisition of skill in presenting Engineering information) for the solution of Engineering problems through experimentation. The student must be made to realise that the laboratory work gives him an opportunity to think, evolve something original, experiment and finally solve a problem.

In view of the tight foreign exchange position, it will not be possible to get necessary equipment from abroad and equip the laboratories satisfactorily enough to develop research. It is, therefore, necessary to start design, development and research units in various branches of Engineering where the equipments required by the various laboratories of the technical institutions in India can be designed and manufactured. This will avoid the delay in obtaining equipment from abroad and save foreign exchange. The research units can develop prototypes and new designs of equipment and produce special equipment for research work as well as supply some equipment which are not readily available. The research units can act as consultants to small-scale industries. Such units can carry out research work in a particular field and the designer in charge of the unit can also guide post-graduate work. These are to be located at places where facilities for post-graduate work and research in the particular field are available. However, the staff and the equipment as well as the facilities should be completely independent of the normal teaching work in institutions. Also such research units should be separately started for each of the different fields of specialisation.



POST-GRADUATE STUDIES: We have now standardized the two year courses. The following suggestions are worth considering:

- i) Candidates for admission to post-graduate courses should have some professional training at least one year, after taking the degree.
- ii) Facilities be extended for the teaching of a foreign language to the extent of the student being capable of understanding and translating foreign technical literature. To begin with, different languages may be introduced in different centres.
- iii) In addition to the written test, the candidates should appear before a Board for VIVA-VOCE test in the field of his specialisation.
- iv) The project work should be on a problem existing in the Industries in that zone and that proper correlation be established between the research establishment and the industry. The assignments given to the students must be different
- v) For Ph.D., the research topic be allotted in the first year, the scholar be asked to study the connected literature, carry out

preliminary work, prepare the report, and get the clearance from the Professor before proceeding further.

- vi) Industries and construction organisations should afford facilities for performing specialised experiments for which equipment do not exist at the teaching Institutions.
- vii) The candidate should report periodically to the faculty about the progress of his work so that the results can be discussed and he can be guided on right lines.
- viii) Before award of a Degree, an abstract of the thesis must be published so that a general criticism of the work could be had before hand. Besides such scrutiny will help to ensure that the work is of an original nature and is of practical value.
- ix) One copy of the thesis be sent to an Engineer engaged in design or construction work for evaluation and criticism of the research work from a practical point of view.

PROFESSIONAL EXPERIENCE.. There is the standing **complaint** raised by the Industries from more than one platform that the practical training given to the students in the Institutions and the skill acquired by them are far from satisfactory to meet their requirements. Some feel that the Civil Engineer should

(i) be taught the basic principles of planning, various methods of drawing up programmes, etc. (ii) be trained in work study, critical path programming, site administration, costing, cost control, and labour relations (iii) be trained in operation, maintenance, and economics of construction machinery (iv) be thorough with factory production of building components, their assembly, etc. Again some others hold the view that the non-achievement of plan targets is due to the unsuitability of our technical education and industrial training. In certain countries industrial experience for teachers, meeting between technical teachers and their counterparts in Industry, and exchange of personnel between Industries and Universities are arranged. On the other hand due to the interest in sophisticated fields like nuclear energy and space exploitation, the curriculum in many foreign technical Institutions has gradually shifted a little away from preparing the students for employment in the bread and butter segments of Industry, such as Engineering design, manufacturing processes and production supervision.

There is no denying the fact that the rapid application of modern techniques in Industry depends upon men trained in those applications and this, in turn, gives rise to the need for a copious supply of high level training and research necessary for any appropriate target. Hence, technological and scientific training must be based on multi-disciplinary

technological universities which will attract the problem of solving industry on the basis of groups such as (i) Engineering Science and Technology, and (ii) Industrial Engineering and Management studies and social sciences.

The Industries will have to remember that the Engineering Institutions have to supply the personnel required in the various sectors and as such the practical training imparted can be only general and broad-based. No Engineering student would be able to acquire any semblance of the specialised knowledge required in a particular Industry even if the duration of his training is prolonged; nor do I consider it to be necessary. Each Industry has to devise its own training programme to suit its specific needs - once it decides to recruit a particular category of Engineers. The Engineering Institutions cannot compress in the small compass of five years, basic fundamentals of Engineering and pure science, specialised instructions in a particular branch, and the vast and varied requirements of the innumerable ever-expanding industries in all fields of Engineering and technology.

CONCLUSION: I am afraid I have exhausted your patience by starting with 'The objectives of Engineering Education' and dealing with a number of subjects which you are sure to discuss threadbare -

during this Summer School Programme. I shall not bore you any more. I would like to conclude by quoting from Dr.R.G. Folsom, President of Renissclear Institute:

"Engineers of to-morrow will be made obsolete by the facts discovered to-day, unless they make up their minds to be students all their life. The difference between the education that many Engineers experienced previously and the education that we are attempting to give to-day, is that when you went to College you were trained to be guides to take people over well-travelled paths, whereas to-day, we are trying to give people the necessary training so that they can become leaders in uncharted routes".

Finally, I wish to express my gratitude to the organisers of this Summer School Programme for having given me this opportunity to express my views on this subject which is of paramount importance for the development of our Motherland at this critical juncture.

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- v) Talk by Sri N.V.Modak at 1964 Annual Session of Institution of Engineers (India), Bombay Centre.

## DISCUSSION

LEO V. NOTHSTINE remarked that an able teacher should put through his points in the right sequence and plan his lectures taking the optimum time for the topic of the day so as to ensure the maximum receptivity of the class. According to him, a good teacher need not be a good research worker but there was scope for a research worker to be a good teacher.

V. C. KULANDAISWAMY remarked that a good teacher with up-to-date knowledge in the field of his speciality contributes as much to the society as a good research worker. Possession of knowledge is one thing, the ability to communicate knowledge is another. Capacity for good teaching should be recognised and encouraged.

Y. ANANTHANARAYANA said that the objectives of each course should be limited in number as warranted by practical considerations and subject to practicability. He also suggested that efficient ways should be devised to measure objectively whether the goals set forth for each course have been achieved, to a reasonable extent.

C. T. SRIRAMULU would like the Industries to give encouragement to Engineering students by providing practical training for them and by allotting enough funds to the faculty to take up Industrial research. He remarked that each Faculty should issue periodical bulletins giving the full technical details of major

engineering undertakings that imply latest and advanced engineering technique. Major projects should find a place either in class assessment or in the final test. He suggested provision of opportunities to the Engineering teachers to visit places and work in their fields of specialisation periodically. According to him, frequent changes of subjects handled by the engineering teachers should be avoided. To have an idea of the efficiency of individual engineering teachers, he suggested that opinion may be obtained from the students through a secret ballot.

S.NARAYANA BHAT suggested that engineering education should be oriented towards producing good practical engineers capable of bringing the results of scientific discoveries into the use of common man, leaving basic research to the scientists.

H.S.SHIVASWAMY said that engineering institutions offering post-graduate courses, degree and diploma courses and the Industrial training institutes that provide training facilities should turn out only such candidates who can readily be absorbed without any overlap in the nature of work expected of each type of candidate. He remarked that engineering education should not imply study of too many and sometimes irrelevant subjects. Regarding selection of engineering teachers, each candidate

should have an experience for a minimum period of three years and should undergo a regular teaching test with prior intimation before he gets selected.

P. PURUSHOTHAMAN showed through a flow-chart that technical people in-charge of the execution of the objectives of technical education should participate in extra research or educational or public services activities in Engineering Institutions so as to complete the flow-chart making it self-generating, reversible and efficient.

ENGINEERING	CURRICULUM	REALISATION
INSTITUTIONS	PLANNING	OF OBJECTIVES
RESEARCH	ANALYSIS	MEN
EDUCATION	DESIGN &	MACHINE
PUBLIC	CONSTRUCTION	MONEY
SERVICE		

He said that the paper clearly presented the objectives of Engineering Education and that the question is whether we can realise these objectives. He was of the opinion that this is possible only when, those



who are in the execution stage, to-day have facilities and leisure to improve themselves by participating in extra research or educational or public service activities, so that when they move to the planning stage, they can efficiently improve the institution's activities and increase the efficiency of the Engineering Colleges.

GOWRISANKAR remarked that the Industries should refer their problems to engineering institutions for solution. He suggested a bifurcation of the curriculum for Mechanical Engineering undergraduates in the Final Year in such a way as to give

- i) orientation towards pursuing higher and advanced studies,
- ii) orientation towards taking positions in industries in different capacities.

S. RAJARAMAN in his concluding remarks said that there already exists an informal evaluation of the teacher by the students. He did not favour the ballot method of assessing the work of teachers. He tried it and gave it up after sometime. With the co-operation from Industries, the reverse flow suggested by Purushothaman was possible. He also said that prescribing previous experience for engineering teachers was difficult in the context of dearth of engineering teachers.

PRINCIPLES OF TEACHING AND LEARNING AS APPLIED TO  
ENGINEERING EDUCATION

K.C. CHACKO

Me dear Colleagues,

The very idea of discussing this subject at a Seminar of this nature, presupposes the existence of a general feeling of scepticism about the suitability or otherwise of the conventionally established principles of teaching and learning as applied to the field of Engineering Education. This must have resulted from reports arising from various quarters about the competence of the engineers trained during recent years in our country. Perhaps I should have stated incompetence, for it is seldom that we receive compliments for a good performance while it is quite often that we are criticised fiercely for even small shortcomings. If the end products, namely our engineer graduates are found wanting, naturally the first place to look for its cause is in the process of their production - in the principles applied and their results obtained in the educational institutions. There might be a variety of causes, converging on this observed end result like, the choice of subjects taught, details of curriculum proposed, numbers involved etc., but these are all laid down by expert high power committees which take into consideration the overall requirements of the country and so the failure, if any, it may be argued lies with greater

probability in the shortcomings in the final process, namely, teaching and learning. It is, therefore, logical and worthwhile to analyse this question in detail and suggest remedies if the current applications of the principles of teaching and learning or the very principles themselves are defective.

My first reaction has been that the principles of education and learning we have been applying in the field of technical education in this country have not been at fault, at any rate not seriously at fault. Considering the immensity of the numbers involved, the limitations in the matter of facilities, equipments and personnel, the performance of technical education has been remarkably good. For a country like ours, vast and challenging in the magnitude and nature of the problems of construction, transportation, adaptation, or accommodation, of necessity there have been compromises. For the idealist or the visionary these compromises appeared as results of ignorance or wrong judgement and largely so perhaps in non-technical minds and this raised the hue and cry of fall in standards in technical as well as general education together with a charge of unsuitability or a question mark on the appropriateness of the methods used. I am an optimist - perhaps more of a realist - but intent on making an effort, however, imperfect or inefficient it be to achieve results. I shall be more

clear and precise. I am one of those who believe that the tremendous growth in numbers in our technical institutions during the last few years is fully justified, in spite of the real serious shortages in the matter of training equipment, in accommodation, laboratory facilities and teachers. No doubt, I concede, with many of you, that in this feverish haste to supply the growing needs of technical personnel in our developing nation, a few incompetent men have also been turned out. Some who might occasionally make costly mistakes even. But, it is to our everlasting credit, that during the last ten, fifteen years of our independence, we have produced engineers who are now at the head of many a flourishing concern of national value. These young men and occasionally women too, who were taught or trained by the older generation among us and who learned, the first lessons mostly under our guidance have done remarkably well; they have not been found wanting. The less qualified have not contributed to vital, irrecoverable damages, while their share of building up might not have been spectacular. But was it not better, that they put up a bad or inconvenient road than that there was nobody to lay it at all. I do not deny the current accusation, that the engineer gets buried in his mistakes and perhaps buries many more along with him and that therefore his mistakes are serious. My only consolation is

branches of the public service. I think even administrators are telling us that the structure of staff in technical institutions should have industry orientations, etc. that management training, psychology training, training in law, are all necessary ingredients of a technical training. They may all be required. They may all be good. I am not questioning them. I am only justifying the inference I have cited above that there is a general feeling of discontent with our end products of to-day and the public, including many of us, think that the root cause of the malady lies in the application of the principles of teaching and learning to engineering education. Solution seems to lie in appropriately modifying these principles or applying new principles.

In attempting to prepare this talk, I read through the reports of the discussion on the same subject at the seminar held last year at Coimbatore. I believe those records are available here and that some of you might have perused them. They deal with the methods now in vogue and the advantages, limitations and improvements to them. No doubt, over the generations the principles of teaching have not changed: they might not seriously change at any time. Knowledge possessed by a man is passed on in stages to a person who knows less. It might be a direct telling - the lecture method - it might be by a

series of interrogation the question or discussion method - it might be by a demonstration of sketches, tools, operations - the audiovisual method. It might be by demanding from the students a suggestion for a way out in a given critical situation, the problem method - it might be by making him responsible to enquire, discuss, negotiate and finally arrange for the conduct and fulfilment of a specified work: the project method. We teachers use all these methods - accepted standard methods - of course with varying degrees of success depending upon individual competence, individual effort, and the nature, extent, and efficiency of the teaching aids like charts, models, films, computers. I do not think that anybody will deny that any of these techniques of teaching is either outmoded or inefficient or self-sufficient. A combination of all these will be the ideal for instruction. On an occasion like this - when we Engineering Teachers are assembled here may I say in a spirit of introspection - we have to ask ourselves the question, have we all been giving off our best in applying these principles even to the best of our ability - to what extent has each individual teacher used these methods subject of course to his resources - and to what extent has each individual administrator cared to guide, supervise, control and supply the resource material to each teacher.

Have we thus given cause for the public to feel that the 'system' needs change? and a radical change at that? or is it that the change is needed in our **appro-**ach to the problem - the motivation in us - the preparation we make - the anxiety we have to 'educate' - the satisfaction or gratification we have in the real fulfilment of our mission. After all education is 'drawing forth' - not creating something in its entirety out of void. It is a commissioning of the latent energy in the human mechanism. It is a co-operative effort - it is a sharing - it is a building up of a social universe by tapping several power houses - several generators for a harmonious whole. The students who come to you, come with an open - sometimes a blank mind - but with an anxious, expectant heart - they have come to you for guidance, for help, for instruction, for example, for ideals; in the very act of their coming to you, they demonstrate the hope that you will enable them to 'live' - to 'come up' and play their part in the community in which they are cast. They repose their absolute trust in your competence and willingness to play the role they expect of you. The success of teachers will be proportionate, to the extent they realise this most essential aspect of their profession. To one, who is fired by this sense of responsibility - this sense of

mission in their life - all the techniques of teaching will be equally useful. And where this sense is conspicuously absent, any technique will be of questionable value. After all - all teaching is personal - an interaction of mind on mind. There is therefore, the supplementary part of it learning. There must be a responsive co-operation from the pupil. Is it voluntary, or can it be induced? We have all heard the saying that we can only take an animal to the stream with flowing waters, you can't make it drink; that the good teacher teaches the dull boy and the brilliant boy alike and that he cannot bless his disciple with a receptivity. These are true. There are varying degrees of receptivity and adaptability. In these days when 'student indiscipline' has become a subject matter for discussion the fact of its existence to some extent cannot be denied. And the question of preparedness for learning on the part of the student cannot be always presumed. But they should be only treated as exceptions. Given the preparedness, what can we the teachers and the planners do to improve the quantum of learning. Here again I am of the opinion that in the ultimate analysis, it is all a problem of human behaviour. I think it was Herbert Spencer who in his dissertation on education made one of these forthright appraisal of it. He says, that the Universal struggle in which the chief



energies of men are spent is to rise above his neighbour and be revered by him. With a slight modification, I am disposed to agree with this statement. Everybody is anxious to be revered by his neighbour. In every walk of life, each one in his plane, feels important and wants to be recognised, to be honoured. We have thus to regard our wards as not an inferior class, just come to be 'taught' but come to be made 'partners' in a co-operative enterprise. Life has to be understood as an overall whole in which our part as teachers is as important and valuable as their part in learning and the atmosphere of oneness - of trust - of love - of service - of solidarity should be created in them. The teacher who goes to a class must be received by the class as a loving and loved partner. It is in developing and establishing such a relationship between the teacher and the taught, that the success of all educational effort lies. This respect can come only if you are a 'good' teacher, one who knows the subject: one who is good at the subject. Any amount of 'other goodness' on your part will be no substitute for your incompetence in the subject. The first requisite in a good teacher is a thoroughness in the subject he is going to teach. You may be uncouth in your appearance, faulty in your expressions, awkward in your mannerisms. The students may tolerate all these provided you have a competence in

your subject and an overwhelming affection and sympathy in your heart. Every effort must be made to improve all techniques, but I am asserting almost dogmatically that if you know your subject very well and with a humility in your heart, you love your students, you will be a good teacher.

My concept of a good engineering teacher, centres round a man who has been able to observe and appreciate a fundamental unity in the processes of nature. I sometimes think in terms of the famous Laplace equation  $\nabla^2 \phi = 0$ . You know that it is applicable to such varied phenomenon as the bending of beams, or the flow of water, or the conduction of heat, or the propagation of electricity or celestial mechanics or again the picture of the tensor or matrix of the stiffness of the members of a framed structure, as affecting its structural behaviour. The engineering teacher must be able to visualise, within himself that he is not dealing with an isolated statement or formula, but that he is introducing his ward to a typical behaviour of a system of which he is a part. He should start talking to the boys of a variety of problems, events, situations, or conditions of an allied nature and try to impress upon them the existence of an unique or common pattern in these cases and try to solve the problems one by one, in many cases based on suggestions from the students themselves.

This in outline is the most dynamic, responsive, co-operative method of teaching and learning. Sketches, charts, models, other aids simulating conditions all are powerful aids which make the teaching more effective. My main emphasis, is that the teacher should make an earnest effort to group together observations from life of an allied nature: graphically describe them to the students, elicit common factors in the events cited and help them to evolve a principle of action. This method will develop confidence and originality in the students. I agree that it is very difficult, especially when the numbers are large. And still variations can be made of the method, with different numbers and different subject: simple questions with a possible one word or one line answer should be framed and all students made to write down the answer. Different answers should be read out to the class and discussed before the correct answer is given. Unless the students write down wrong answers, there will be no realization of their ignorance and the desire to learn will not be stimulated. They will think hard to write down correct answers because they invariably long for the honour of being spotted as the knowing one in the group. These are, however, minor details. The good teacher who loves his students will be always on the alert to possess all modern aids to pass on knowledge - be such aids material based on psychological.

One great field for effective work is in creating proper attitudes and responses in the students in their attitude to learning. You could train anybody to be a good listner: to be a great participator; to be a great co-operator.

Any critic of the present state and system of engineering education must not forget that this nation is being compelled to crowd into a five year Engineering course, a knowledge of the subject from its fundamentals to the latest techniques. The fundamentals cannot be presumed, cannot be belittled, cannot be reduced. The developments have been so vast that they cannot also be condensed, nor adequately covered. Necessarily, therefore, till such time, as our homes, the countryside and public places have advanced technologically sufficiently that fundamentals of engineering knowledge become common place, the system of our engineering education cannot change substantially. The country cannot afford the luxury of a more leisurely or long drawn education to cover more of the developments. Practical training and apprenticeship must continue to fill up normal deficiencies in the product. At the higher levels of Engineering Education, it is not the skill of a mechanic, a ready made repair expert or fabricator that is needed, but it is of one who can gauge a situation and face it intelligently and profitably in the interests of humanity. It is

not desirable to increase the extent of mechanisation in education or psychiatric incursions into it, like making a recording machine repeat a formulae from under the pillow of a sleeping student, to imprint upon his memory unintelligently through, a difficult formulae. The individuality, the free will, the right to choose and act these are equally important as the blessings of progress in the material plane. Any system of education, method. or technique shall not compromise on it. Every technique will pay, when there is basic intrinsic sincerity on the part of those who apply the technique and on those on whom these techniques are applied. Such sincerity is the product of all the influences generally connoted by the term civilization.

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## DISCUSSION:

K.M.BAHAUDDIN stated that intelligent students are admitted to Engineering Colleges. He asked why many fail? He attributed the cause to the defective teaching methods. He felt that if the methods of teaching are reoriented in accordance with the needs of the present days, it would help the students.

LEO V.NOTHSTINE said that the teacher should be dynamic. The students must not be allowed to rest with having understood but must be made to generate ideas.

Md. SULAIMAN said that the teacher must outline his lectures before hand. The co-operation of the students is also necessary for the success of the teachers.

He asked, when a student has learnt all his subjects in P.U.C. in the state language, how best can he be taught in the Engineering College in English.

S.SANKARALINGAM said that before start of a lecture there must be meeting of minds. For this he wanted the students to be questioned to know whether he has understood the previous lectures. The feeling among some students that they will be thought low of by the co-students if they raise doubts, must be removed.

E.C.CHANDRASEKARAN said that if the teacher can impress on and motivate the taught, success is achieved. He cited the example of Ramakrishna and Vivekananda. He felt that a good teacher must be a good student himself.

T.R. NATESAN said that teaching methods must be so arranged that it will be useful for the intelligent as well as the below average and that the fear in the minds of the students must be got rid of.

A.S. RAJU suggested that there may be an Advisory Board set up to review the activities of the students in High Schools to see whether they could be diverted to Engineering or Medical or any other Professional line. He said that stress on fundamentals is essential and the syllabus should be oriented to that end.

In his reply K.C. CHACKKO asked why there is a wastage by failures in the Institutions. According to him, increased strength is one reason. He was of the opinion that judging of the teacher by the end products in the present day context is wrong. Teaching to a large number in a limited time, a written out syllabus without much contact with the students cannot produce good results. But he justified it since they are catering to the present needs of the country.

He said that it is difficult to make the student realise the unity in apparently different phenomena. But according to him the teacher in his mature state of mind, can perceive the existence of an universal law interconnecting many phenomena found in the various subjects.

He felt that students are dishonest partly due to the low standard set by the parents and that they must inculcate the sense of honesty in the homes.

# THE PRINCIPLES OF TEACHING AND LEARNING IN EDUCATION

J.D. SMITH

INTRODUCTION : It must be made plain from the start that this lecture is delivered by a plain teacher from a teacher's point of view. Education must be the easiest subject in the world to talk about and theorise on. Teaching and learning are practical activities and so theory, if it is to have any value, must be tied down to what is feasible in the class room. Consequently, all I propose to do in this lecture is to raise one or two points, a few loosely related themes, which have occurred to me when working as a teacher.

## P A R T I

AIMS OF ENGINEERING EDUCATION: Let us get right down to brass tacks and ask ourselves what is the purpose of an engineering education. The answer is very simple and reasonably well-defined. It is to train people so that they are competent to do certain jobs in Industry and Government services. There is a notable distinction here between engineering degrees and more academic subjects. What is the purpose of a degree in Science? Is it to train a man to be a Scientist? I doubt it, I doubt very much whether college lecturers ask themselves, "Will what I am saying train these people to be Scientists?" On the contrary, as a rule, he is occupied



with communicating accepted scientific principles. This is important, he teaches science, he does not train Scientists. Whether or not this is the best approach does not concern us to-day. Academic first degrees are part of general education.

The Engineering College lecturer has a vastly different task. His aim is (say) to train his pupils to become working Civil Engineers, able to design, direct and supervise the construction of a dam. And he has to teach sufficient theory to last a lifetime of practical applications, for his students will gain no further opportunities for learning theory. This aim may sound ambitious, but at least we have a clear idea of what it is, and that is unusual in education.

Incidentally, you must not assume from this any derogation of the role of general studies in an engineering course. However, their aim is sub-ordinate to, and supporting the objective of, creating engineers.

To sum up, the principle of teaching in engineering education is to teach the students what they need to understand and know for the job they are going to do. The principle of learning is to understand and learn it.

Pinning my thesis down now, I have to answer the question 'How can you carry out such a programme?' Teaching a man the history of India is one thing, teaching him how to design and construct a dam whose purpose he has

never thought of in a place he hasn't seen is quite another. And there are only four years in which to train him.

A first simple requirement seems to be careful design of the curriculum and its steady revision in the light of industries' need.

ILLUSTRATION: PARTIAL FRACTIONS: Let me draw an illustration from my own experience teaching mathematics to engineers. In practically all syllabuses above the elementary, Partial Fractions as a technique for integration is taught. To learn the subject thoroughly takes about four hours lecture and double that tutorial or home work. I have taught it many times and wondered why. When will an engineer use partial fractions? After thinking long and hard about this I came to the conclusion never, or at best hardly ever. The reason is simple enough. The integrals of this type which one has to perform in practice, generally have a quadratic denominator and so are more tidily integrated using inverse tangent or inverse hyperbolic tangent functions. One can add a further reason that engineers seldom have occasion to approximate more closely than the second power and that is why the most complicated polynomial is quadratic.

As a matter of fact as an engineer I have on only one occasion met a use of partial fractions. It occurred in a rather complicated investigation on the economics

of oil firing blast furnaces. The integral was

$$\frac{dx}{1-x^4}$$

A colleague of mine found that it came up in the solution of one of his problems. However, he was a physicist, had not done any serious mathematics for seven years or so, he had almost forgotten how to integrate. So he went to a friend in the office next door. The friend said 'Oh-er-use partial fractions - kind of split it up you know'. Well, the friend could not actually show him how to do it, so my colleague wandered from office to office either meeting a blank or at best a few vague remarks until he came to a mathematician. The mathematician just glanced at it, split it up in his head, and said: 'Well, the answer must be:

$$\frac{1}{2} \arctan x + \frac{1}{4} \log_e \frac{1+x}{1-x} + \text{a constant}$$

So you see in the very unlikely event of an engineer meeting with a partial fractions problem he can telephone a mathematician and get the answer in five minutes. Even if there are not any mathematicians around I am certain he could go to the library, get a book, and work out the answer for himself in less than twelve hours (the time it takes to learn all about partial fractions).

It could be argued, of course, that from a general educational point of view partial fractions are an

inevitable part of mathematical development. However, as practical engineers I feel we must approach with deepest suspicion any argument 'from a general point of view'. And as a mathematician I know that 'partial fractions' is an unimportant little technique I have hardly ever had occasion to use. We can go further and say that for the mathematical education of an engineer the student would be far better getting to grips with the importance and applications of Fourier Analysis and Laplace Transforms, or even gaining some idea of the shape of Bessel functions.

I have laboured this point for the sake of illustration. I am not running a campaign against teaching partial fractions but showing rather that one little point in the curriculum may not stand up to close examination. There must be many, many others.

**CURRICULUM FORMATION BY FEEDBACK:** However, I am not suggesting that we can glance through a curriculum and judge from our own knowledge what is worth teaching and what isn't, just by thinking about it. How are we to judge then? Since we are contending that engineering education is to train men to be engineers in industry, that is where the answer must come. This is the main point at which feedback from industry is essential.

It can be pictured as a semi-closed loop thus (Fig.1). Just how this feedback can come about is a question for the country concerned, its industrial and professional

mores. One thing is clear. You cannot just 'ask industry'. There is no particular thing to ask. But in practice it seems almost self-evident that the most useful feedback can come from working engineers. They and they alone really know what part of their training proved useful and what did not, and what problems they have met, for which, their training left them unprepared.

ILLUSTRATION : TECHNICAL EDUCATION IN BRITAIN: Technical education in Britain set down its roots in the 1840s, at the same time as Engineering College, Guindy. More or less at the same time universities began courses in B.Sc. (Engineering) and the Royal Society of Arts started what we would now call craft and technician training. These two activities grew slowly, the technician training grouping to higher standards, until in the twenties, thirties, and after the second world war they really began to flower. Industry was becoming technologically based. The technical colleges rose to provide the training for the men needed. To simplify the picture we shall confine ourselves to 'first degree' level work. (To complete the parallel a British First Degree is roughly equivalent to an Indian Second Degree).

The present position is that there are two different kinds of degrees provided by two different kinds of Institutions, neither of them like an Engineering College. Universities grant the B.Sc.(Engg.) and Colleges of Advanced Technology, the B.Tech.

Universities in Britain are much the same as Universities anywhere. A College of Advanced Technology on the other hand provides an extremely wide variety of the more advanced Technological Courses, various diploma and membership courses, engages in a certain amount of research, but above all is practically based. One of the interesting things about the two qualifications is that for getting a job a B.Tech. is extremely useful whereas B.Sc.(Engg.) is worth very little even though it is far more advanced academically. The reason for this is really the main point of this passage in my talk.

Almost every profession has its own Institute. These institutes are really guilds for maintaining the standards of the profession concerned. In order to become a fully fledged professional you have to be a member or associate of your professional institute. The result of this is that all professional courses and examinations have to be designed and revised in consultation with the appropriate institute. What is more, the institute has the final word, for, if it refused to recognise a qualification, then that qualification is almost valueless. The Institutes in turn are composed of members and associates electing their own committees and office holders. This is where the feedback operates. Practicing engineers are the best people to know what this training should provide, and they can make sure it is provided.

You may recall I said that a B.Sc.(Engg.) is not a very useful qualification as it stands. This is true; but after two years or so, of industrial experience the B.Sc. (Engg.) can gain his associateship without further examination. This brings out two points. First, the institutes insist on a measure of practical attainment. Second, the B.Sc. course itself must be approved by the institute as a theoretical training.

An interesting side line to consider is that B.Sc.'s have always been a minority of engineers and not the elite of the profession, more the specialists and researchers. The vast bulk of (for example) mechanical engineers get their basic AMI Mech E qualification through their own studies, correspondence courses, night school and industrial attainment. The effect of this is that you have a practically based profession controlling the B.Sc. and B.Tech. courses, yet tapping the extra dimensions which the more academic sources provide. The system works thus (Fig.2.)

I have painted a very glowing picture and of course I must qualify it. No system involving human beings works as well in practice as it should on paper. The institutes also have the normal weaknesses of semi-democratic institutions. But, still they are basically sound. The needs of the profession are frequently up-dated and if anything goes seriously wrong there is a mechanism for the profession to do something about it and it provides a channel

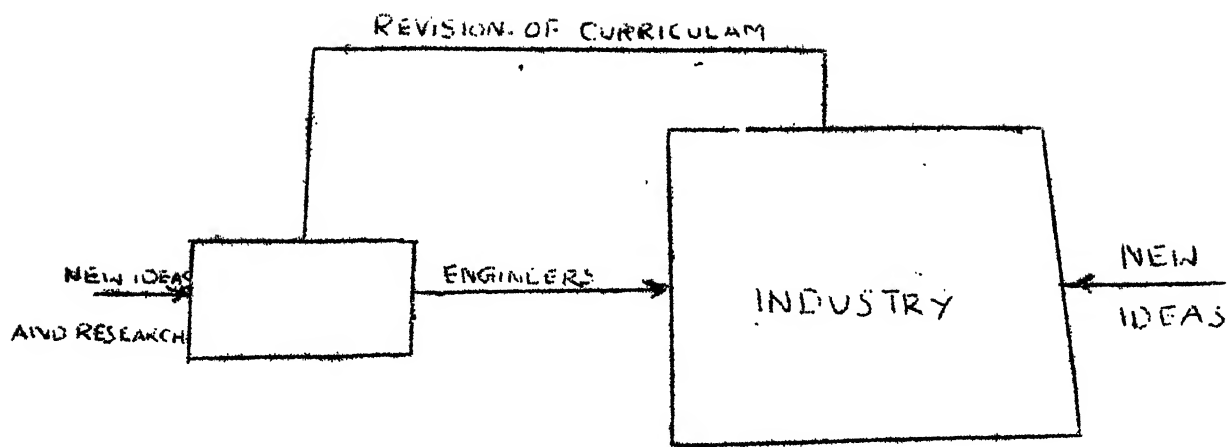


Fig. 1

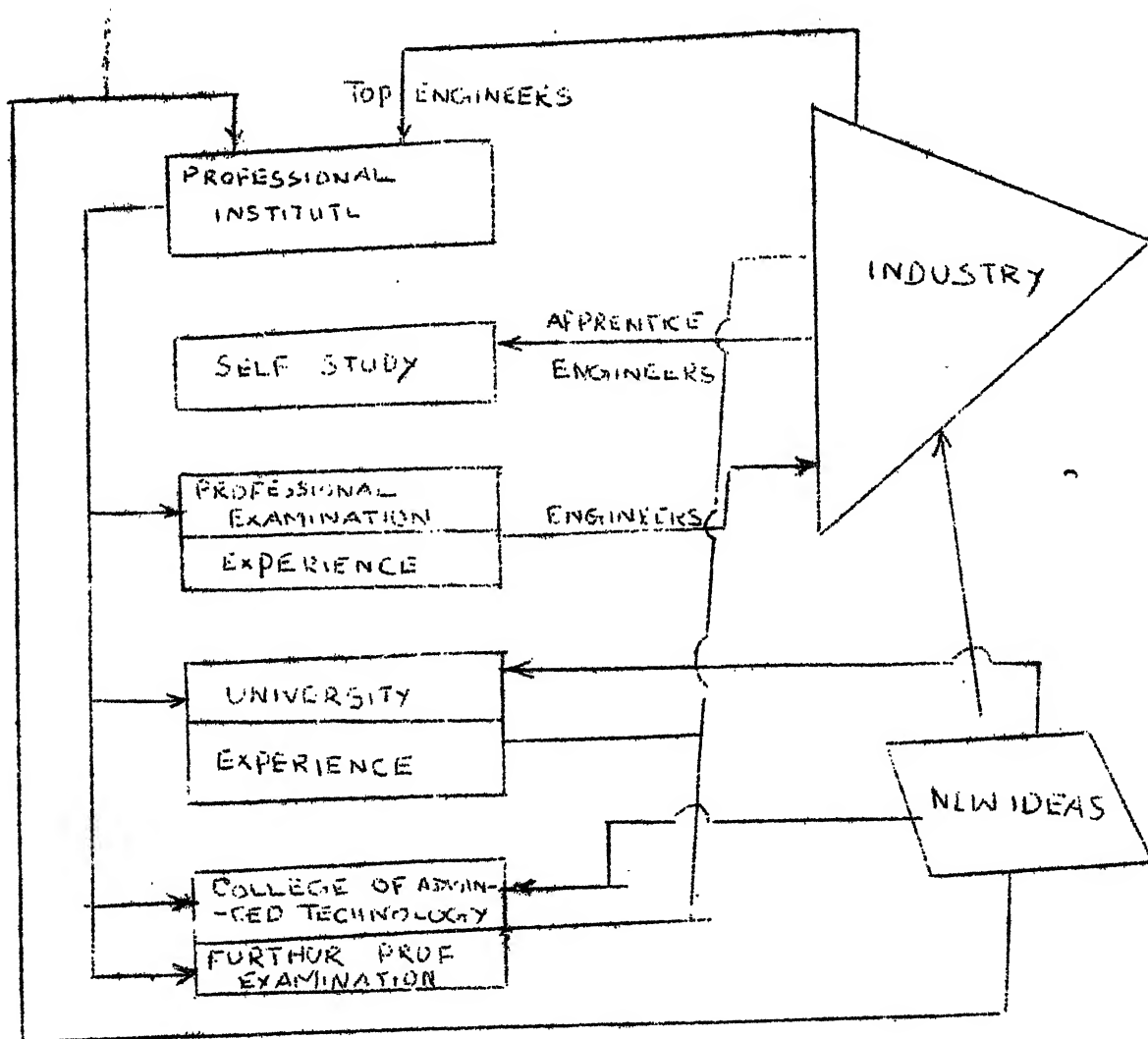


Fig 2



for ideas and a body for consultation.

Incidentally, all British mathematics for engineering courses I have met, teach partial fractions.

That then is my first theme, that a professional training should be supported by the profession itself and based on practical achievement, otherwise it is very likely to wander from the needs of the profession. I have described how this works in Britain. Other countries have other approaches; it is a question of the structure of the country concerned. But as an engineer I am bound to advocate an automatic feedback mechanism. Reading books and thinking about is not likely to provide the correct adjustment.

## P A R T II

My second theme concerns the practice of teaching and is not really confined to engineering.

OPEN-ENDED TEACHING AND LEARNING: We are all suffering the effects of an attitude of mind which has its roots in Western Europe before the Reformation. This is to regard teaching as imparting a known and certain body of knowledge. I do not think this should be done in any subject. The most important part of learning, surely, is realising what you don't know and what is not known. Such a view can be justified in purely educational terms as a training for leading a full and useful life. However, when you move

across to sciences whose very nature is discovery, or to engineering, a problem-solving and creative activity, the open-ended approach to teaching becomes not just desirable, but essential to do the job.

You may recall that early in this talk I said that one of the aims of engineering education 'is to provide sufficient theory for a lifetime of possible applications.' On the face of this is impossible for two rather obvious reasons. The first is that in four years of pure theory teaching one could not impart the knowledge necessary for coping with all conceivable situations let alone the inconceivable, the ones you hadn't thought of. There are just too many possibilities. The second reason is that theory itself is changing with time. In twenty years, your students will almost certainly be using different techniques for solving problems from those they use at the moment. To cope, therefore, it appears necessary that the teaching of engineering theory should be directed more at enabling you to learn what you will need to know than just imparting facts which might be useful.

Now, to get down to the classroom level, what does this amount to? It sounds simple enough, the basic factor is the attitude of the teacher himself. I often get letters in from people asking 'to get acquainted with the most modern techniques is science teaching.' The real answer (though I am never impertinent enough to give it)

is that competent teaching is not really a matter of technique. Simple chalk and talk can be dull or amusing, soporific or inspiring, but if at every point we convey to our students that all we are describing is the present state of the art and a limited part at that, we have taken a first step in the right direction.

Let me illustrate. Suppose we are teaching oscillating circuits. Then we must say that what we teach is a good solid method for a median range of frequencies but that for very high and low frequencies there are much better methods. We must add the hope that in the future better methods using fewer components will be developed. Furthermore, on deriving the formula for impedance we must point out all the simplifying assumptions we have made and stress that the formula is only an approximation. At the end of such a lecture we are duty bound to provide a reading list for those who want to explore more detail. Only a few of the best students will be seen in the library exploring the subject. But in later life, on the job, time after time the engineer meets a situation which his training doesn't quite fit, yet if he can skim through his notes and find what book he ought to look at, then his problem is almost solved. Indeed it is my contention that if we teach our students just to use library catalogues and the indexes of books we have gone most of the way.

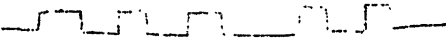
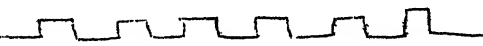
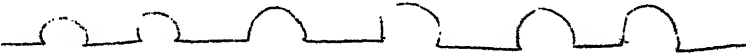
That is sufficient, duty done as a lecturer. But to be good teachers we cannot content ourselves with just telling the students their subject is open-ended. We must make them actually experience discovery for themselves. The extent to which this can be done has to be calculated carefully. Taking the doctrine to its logical extreme, at the beginning of a course in mechanics should we present the students with two billiard balls each and tell them to go and discover Newton's Three Laws of Motion? Of course not, none would succeed (or perhaps a genius would discover Einstein's Law instead and confound his teachers). The basic steps of almost any subject require a profound insight, given to only a few.

ILLUSTRATION: NEWTON'S FIRST LAW: Even so at a simplified level we can go part of the way. For example in teaching Newton's First Law, put a block of wood on the bench and give it a push. 'Why does it stop?' These days you are bound to get the answer 'Friction'. Ask, 'What if there were no friction, what would happen then?' You can see that adding a few questions about direction Newton's first law can be drawn out of the class in a few minutes. Strictly speaking this approach is illogical. We all know that the concept of friction really follows the assumption of Newton's first law. But, nevertheless the student will have got the message. Historical corrections can follow later.

ILLUSTRATION : WAVEGUIDES: That perhaps was an oversimple example which everyone knows. To illustrate how the approach extends, let me suggest how a really difficult subject-waveguides - can be taught.

Naturally, you all recall that a waveguide is a tube of carefully chosen dimensions down which an electromagnetic wave of high intensity can be conveyed with hardly any attenuation. Thus boldly presented, the idea seems utterly ridiculous and implausible. One cannot imagine how or why it should work, and the change in transmission line concepts from a couple of wires of carefully chosen length to a rectangular tube of certain dimensions is, to say the least, odd.

One way of teaching it, and a good way for an engineering course, is to adopt the 'problem solving' approach.

As you know, one of the most important technical problems in radar is to preserve the square shape of the wave you are transmitting, thus  it is not too difficult to generate a good square wave, and once transmitted from the aerial, the wave doesn't lose its shape much. However, in getting the wave from the square-wave-generator to the aerial; conventional transmission lines attenuate the components of the square wave so that what set out like  finishes up like 

You also have good many other problems. A transmission line at ultra high frequencies will itself transmit and interfere with the transmission from the aerial (Fig.3).

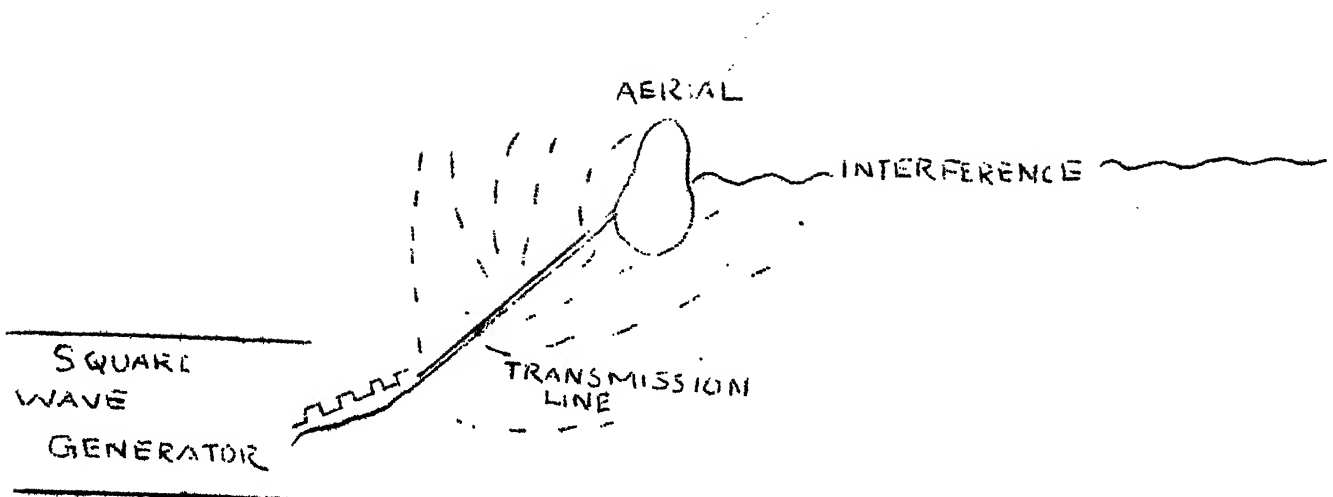


Fig. 3

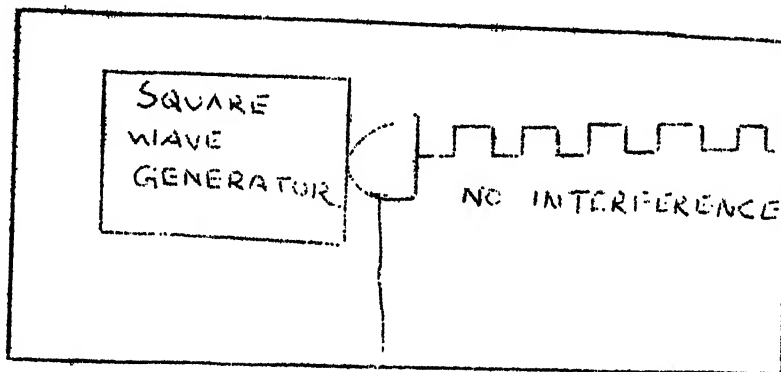


Fig. 4

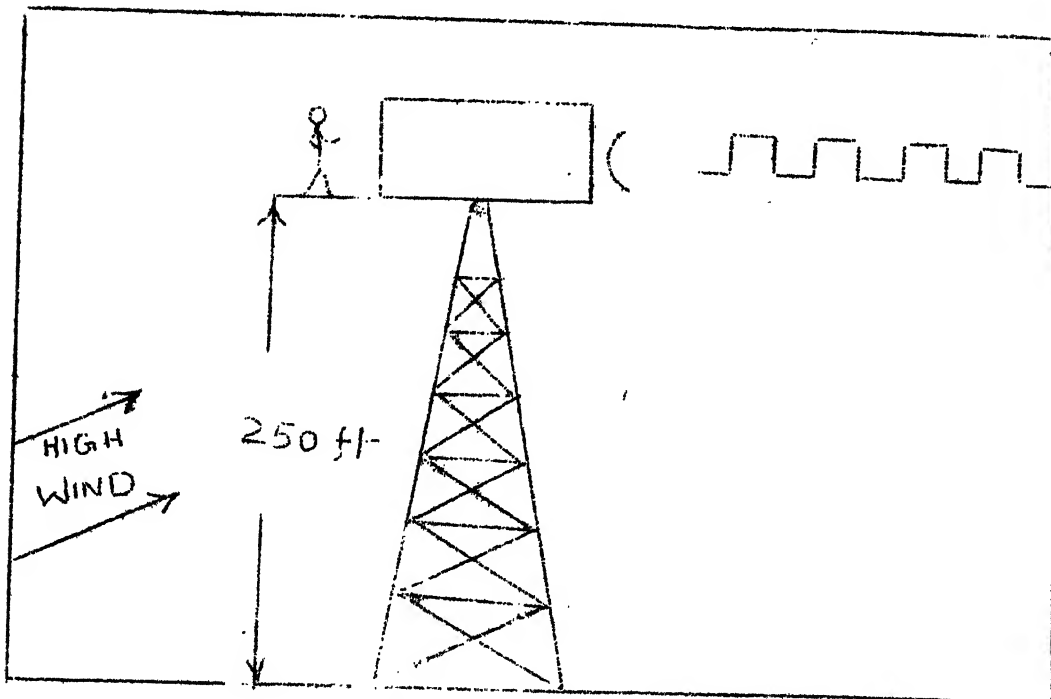


Fig. 5

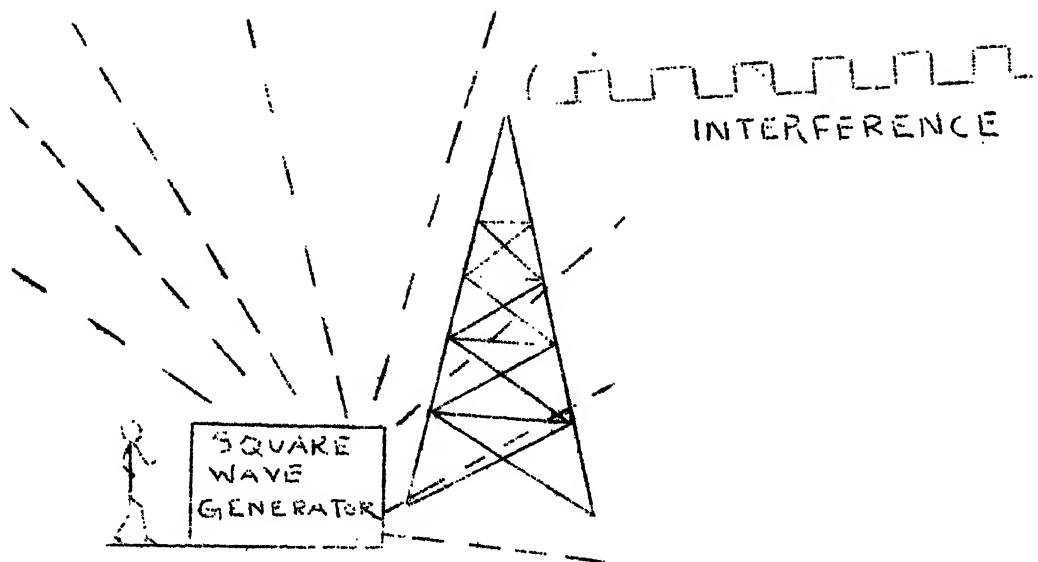


FIG. 6

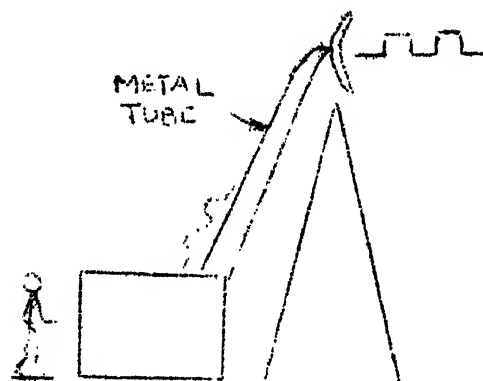


FIG. 7

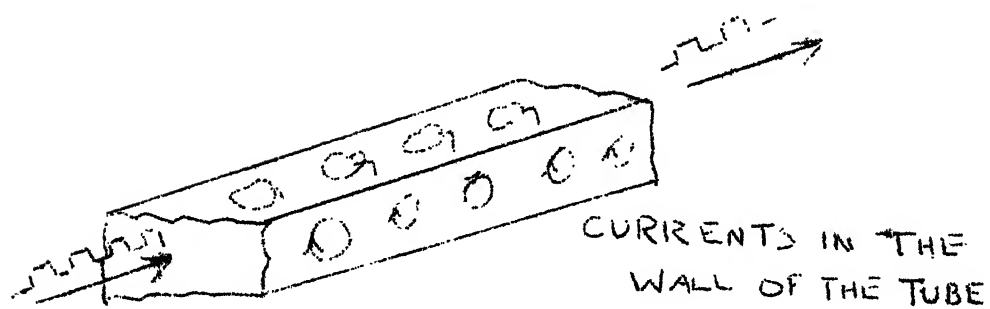


FIG. 8

So you have a typical problem. 'How can you get a wave from the square wave generator to the aerial without having interference problems and serious attenuation?' If this question is put, it is easy enough to get the answer 'Make the transmission line as short as possible.' And you have Fig.4.

However, this happy state of affairs is seldom possible because a square wave generator is a bulky affair, radar serials have to be set on high towers, and as any structural engineer will recognise (Fig.5). So what to do?

Take up the idea of having a transmission line as short as possible (Fig.6).

Suppose you had no transmission line at all, and you just transmitted square waves from the end of the generator. Well, some would get to the aerial and be transmitted, but firstly the interference would make effective transmission impossible, and secondly the power of the wave is reduced according to the inverse square law.

Deal with the first problem first, 'How can you cut out all the waves except those which go to the serial?' The answer to this is very simple. Metal is opaque to ultra high frequencies, so if you enclose the transmission within a tube you should cut out most of the unwanted radiation, thus (Fig.7)

Next the power loss problem. This raises the question 'what is happening to the power which is not



being transmitted at random as before?' Answer is well known and obvious, 'There are currents on the inside of the tube, the tube will get hot'. (Fig.8).

From here it is an easy step to suggest these currents can be used to reinforce the wave in the tube by choosing the dimensions properly so the currents cancel each other, and so you have wave guides.

I am not suggesting that this is a model way of teaching wave-guides; it is no more than an indication that difficult concepts can be taught in the spirit of engineering, a problem-solving creative activity.

#### DISCUSSION:

V.C.KULANDAISWAMY said that a subject can be covered either by sector method or by concentric method. The speaker illustrated the methods with respect to hydraulics. He said that fundamentals of hydrostatics must be given just enough to make the student understand free surface flow and the closed conduit flow. Then measurements must be taken up. He pointed out that on the contrary at present, after covering hydrostatics completely, measurements are taken up without giving the necessary concepts of liquids in motion. It is because we follow the sector method. The concentric method will be desirable in a number of cases. A student should get first an idea of the scope of the subject and the chapters should be covered in small steps. He suggested that the subjects

must be taught in proper perspective with proper explanations for all assumptions. He felt that the philosophy underlying each subject must be well brought out.

L. V. NOTHSTINE suggested that the teachers should cover the subjects properly without gaps.

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## PLANNING AND ORGANIZATION OF INSTRUCTION

A.L. KRISHNAN

An extract of the speech is given below:

A.L. KRISHNAN said that different professional instructions need different organisations. He cited the example of Arts, when the students may be grouped and put under tutors to do certain amount of reading by themselves within a prescribed time limit, whereas in engineering, however, a special organisation is needed under an engineering expert as the Director of Technical Education. Beyond the five or eight hours of work in the college, the students should be watched as to how he spent his time and his energy during the rest of the period. In this context, he felt that residential universities are the best. The third aspect of organisation was the ability of the Institution to stand by itself in teaching certain courses without a syllabus drawn by external source. He said that this would help the teachers to build up originality and individuality of their own.

Turning to Planning he felt that in our country we have too large a number of students in any one class room. Smaller number would be conducive to discipline and that this would help the teacher questioning the students and vice-versa. He also suggested that the students could be asked to prepare the lessons early and one of the students could even be asked to lecture. This would help the teacher to know the difficulties of the students

and in some cases he would make himself understood better than the teacher. The parent should be informed about the progress of the student. He felt that a sense of satisfaction must be created in the student and that he must feel better about the work that he had done and achieved. The teacher has a variety of students to deal with: the intelligent, the less intelligent and the dull. The teacher must devise his own methods to deal with these two or three categories. According to him the institution of fines, threats etc. and creating a sense of fear in the minds of the students would not be an advantage. He urged that the students must be won over by love and affection.

Talking about the examinations, he said that a question paper could be in two parts. One part must contain questions for the average student so that he could pass easily if he had been regular and the other part might be for the intelligent. He wanted the same attitude to be adopted for marking also, liberal for the first part and niggardly for the second. He said that the teacher should be free of slovenliness of any form. He was of the opinion that then only he could vitalise the students and impress them.

## DISCUSSION:

S. NARAYANA BHAT felt that our Engineering course was not well integrated though they talked a lot about integration. He urged that specialisation should be only in the graduate level. He wanted the framing of the timetable to be properly done so that heavy subjects could be taught during morning hours.

R.P. ARTHUR wanted time to be spent in the preparation of time table so that heavy subjects could be in the fore-noon. He suggested that the students should be seated within the class properly so that they could have a full view of them. He was of the opinion that a proper book must be selected so that student himself could follow with a little help. He urged that a lecturer must prepare his own notes and the students should be compelled to take notes. Some classes may be arranged for students to prepare on certain topics and delivering the lectures themselves. These classes would help to remove the fears of students to ask questions in regular classes. He felt that there should be objectives at all levels and that this would prevent a lot of wastage now prevailing in Engineering Colleges.

S. RAMA GOWDA said that it is impossible to cover the syllabus completely. He wanted free exchange of ideas between the students and the teacher.

C.T. SREE RAMULU said that a text book must be prescribed and reference books must also be given.

Y. ANANTANARAYANA wanted the lecture plan to be prepared first.

S. SANKARALINGAM suggested that students should be known intimately by names and not by numbers. He wanted them to be encouraged to work by themselves. To make them think for themselves he said that certain data in problem could be omitted. He wanted the syllabus to be covered in an orderly way.

Summing up A.L. KRISHNAN said that the question of slowing down at the beginning and crowding at the end of the year should not occur, and the same rate should be maintained from the beginning to the end. He felt that if the teacher could impart instruction properly, the students would have a lasting respect for the teacher. According to him all details regarding conduct of classes should be left entirely to the teacher.

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## PLANNING AND ORGANIZATION OF INSTRUCTION

CHANDRAN DEVANESAN

The following is an extract of the speech:

Regarding planning, the speaker said that the Cafeteria and the Auditorium are the results of good planning. So also he felt each institution and each individual must be permitted to plan. According to him the establishment of a planning and public relations office in every institution will help in many ways. As in Britain, in India also, he wanted the public and the state to take a good amount of interest in higher education. He urged that the people in the Institution - the various faculties - must have the autonomy to plan freely. He was of the opinion that educational research is necessary for proper planning within the institution and that a willingness to criticise our own institution is essential. He wanted our achievements to be analysed and our progress to be examined and that self-examination to be made at all levels. He suggested that all members of staff must think of the progress of the institution in different directions and that they must plan on proper staff structure. According to him in Christian College there were four different categories:

- i) Research Staff
- ii) Teaching Staff
- iii) Administrative Staff
- iv) Students' advisory and counselling staff.

Then, taking up the question of organisation he wanted to know who should be responsible for the content of the instructions. He said that colleges must be given freedom to form the syllabi and the freedom to examine the students. He felt that this may not be possible in India now. But yet, he was of the opinion that the University could set up expert committees, to whom the Colleges can submit their syllabi and upon examination, the University could recognise the colleges for certain courses. Certain amount of autonomy, variety, freedom to choose and to act must be given to Colleges. He said that the University Grant Commission had backed this suggestion.

He felt that the set up of departments in various colleges, a legacy of the British rule, was not very good, since the subordinate staff of each department have no freedom to express their own views. He felt that this needs reorganisation for the institution to be dynamic. He suggested that a course of psychology for young teachers would be good. He wanted the seniors to discuss new teaching methods with the new entrants as this would help to develop the young teacher. He felt that he must be helped to organise, prepare and plan his lectures.

If the students were to be made to exercise their maximum effort in learning, education must be a dialogue and not a monologue and the student must be made to feel free to ask questions.



## DISCUSSION:

S.T. NAGARAJA said that as conditions prevailing in India are far different from that in foreign countries, it might not be good to transfer the power from the University to the Colleges.

M. NALLUSAMY said that it was better to teach a portion or a part thoroughly than a lot in a superficial way. There must be a sequence in presentation. In teaching he said that it is better to proceed from known to the unknown. He said that teachers should bear in mind that in a class, greater percentage are attentive only during first 15 or 20 minutes.

P. PURUSHOTHAMAN warned that planning without execution in a limited or allotted time would be useless.

H.S. SHIVASAMY said that if the educational system was decentralised and more autonomy given to the colleges, the conditions would improve even though there might be abuses to start with. He also felt that this would help the maintenance of discipline among the students.

N. JOSEPH wanted, after introduction of the subject in every class, the students to be questioned and answers elicited. He said that this would be conducive to better discipline.

T.S. VENKATRAMANAN said that a teacher must be well versed in his subject. He wanted them to think of their bad teachers and avoid the bad points noticed in them.

Syllabus drawn by individuals or colleges themselves might not be better than the syllabus framed by the University, as they were also framed with the best intentions. There should be sincerity on the part of students as well as the teacher.

Summing up CHANDRAN DEVANESAN said that teachers must remember that they were also young once. He wanted a stern face in the class to be avoided and a sense of humour to be maintained. He also wanted audio-visual equipment to be freely used.

Universities should continue to supervise. But, framing of syllabus and conduct of examinations would be better left to the individual institutions and he suggested that conducting convocations in the various colleges would be more meaningful and a greater human relation would be built. University must act as a wiser parent giving more freedom to its colleges.

To be a successful teacher, he wanted the teacher to

- i) Do what they wanted their students to do
- ii) Understand the younger generation and be ready to learn from them
- iii) Remember their own teachers and try to emulate or better the good ones they had
- iv) Get students also interested in their problems even though they might be personal
- v) Get interested in the troubles of the colleagues and understand their worries and problems.

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## DEVELOPMENT OF ORIGINALITY AND RESOURCEFULNESS

K. SREENIVASAN

I am grateful to the organisers of this Summer School and to Mr. Muthian for asking me to give a brief talk this morning; I hope that what I may say will be in keeping with the objects for which the School has been organised and with its programme of studies.

In Western Europe and North America, the summer is the best part of the year when the sun is welcome and nature is at her best. It is the period of the long vacation for educational institutions when students and teachers go on their annual holidays. The summer School, therefore, offers the teachers a welcome opportunity to travel, to meet their professional colleagues from other institutions and to combine professional activities with social functions in suitable proportions.

### THE COOLER PART OF THE YEAR PREFERABLE:

But summer in India is the worst and the cruellest part of the year when one can hardly be expected to be at his best either in physical activity or in intellectual effort. If we should derive the greatest possible benefit from these conferences and group discussions, the most suitable time would be between November and February. If, however, these must be held in the summer months, a hill station will be a suitable venue as people can work

efficiently free from the discomfort of the sultry weather. The aims of the school will be better fulfilled. The hill station also stands to gain in having scientists and engineers from different parts of the country who will take to it a few weeks of intellectual activity - a big change in their normal life.

#### MATTERS RELATING TO ENGINEERING EDUCATION:

A great deal has been and is being said and written on engineering education in every part of the world after the Second World War and as a consequence of it. Many books and periodicals have been and are being published on the subject, specially in Europe and North America. Your discussions during the last four days since this Summer School was inaugurated on 21st June, will have covered the subject exhaustively. So, there is nothing in what I shall say that you do not already know well.

These discussions in the press and on the platform deal with the various aspects of undergraduate and postgraduate engineering education and research - the advances that are constantly being made in the different branches of engineering; the changing requirements of the country and the community; the age and the educational stage at which a student should start on his engineering education; the durations of the undergraduate and the postgraduate courses; the nature and the content of the syllabus taking into account the advances in the field and the needs of the country; the place and the proportion of the 'pure'

sciences in relation to the engineering subjects; the relative emphasis as between the general engineering subjects and the subjects of specialisation; the apportionment of the working week to lectures, laboratory exercises, project work etc. the nature and the duration of the practical training; and most important of all the creation and the maintenance of a high level of research activity and the atmosphere of research.

#### THE IDEALS AND OBJECTIVES OF ENGINEERING EDUCATION:

These are, in the main, no different from the aims and objectives of any other type of education - to make the student a person of high character and integrity; to develop in him a high sense of duty and responsibility to his country and to his fellowmen; to stir his imagination and bring out his latent originality and creative ability; to foster mental alertness, a broad and objective outlook and the capacity for bold and independent thinking and working on his own; to assist him to acquire a good understanding and knowledge and experience in those branches of engineering for which he has the necessary aptitude, and which will enable him to earn his livelihood in some form of service to the country and the community.

Equally necessary are courage and resourcefulness in meeting new situations and unexpected difficulties, the habit of sustained hard work, the ability to get on smoothly with people of diverse types and the ability

to express himself in writing and speech in clear and direct language.

In addition to these which are common to every type of education, the education of the scientist is directed to the study and the discovery of the phenomena of nature and the laws that govern them. In the education of the engineering the emphasis is on the application and the utilisation of the discoveries and the theories of the scientist for the advancement of industry and the material welfare of the people, and for ensuring the safety and the security of the country. There is no clear cut line of demarcation between the scientist and the engineer; many scientists are excellent engineers; and many engineers are good scientists.

#### ORIGINALITY AND RESOURCEFULNESS:

In this talk, I have been asked to deal with the question of the development of originality and resourcefulness in the student. These two qualities are specially needed in the engineer; and the student must be encouraged to cultivate them by constant practice in thinking and working on his own.

Till recent years, the work of an engineering college was limited to running undergraduate courses in civil, mechanical, electrical and electrical communication engineering. These courses were meant to meet the needs primarily of the main employers of engineers -

the Public Works Departments of the Central and the Provincial Governments, the Railways, Electricity Undertakings, the Posts and Telegraphs Department, the Radio Services, etc. In most of these services, the normal work is mainly of operation and maintenance.

Engineering Colleges, therefore, intended to emphasise the acquisition by the student of knowledge, information and data originated by scientists and engineers in other countries, and not so much on his obtaining a good insight into, and a correct understanding of, his subject and on developing his ability to think and work on his own. The examination system also tended to be more a test of what he can remember and reproduce, than of his understanding of the subject and his ability to apply theory to practical problems.

The situation seems to be slowly changing; but even now the student's primary aim is to study to pass the prescribed examinations than to obtain an understanding of his subject and make himself an expert in it.

#### MEASURES FOR DEVELOPING ORIGINALITY AND RESOURCEFULNESS:

To enable the student to develop his capacity for independent thinking and to work on his own, the following will, I believe greatly help.

Undergraduate and postgraduate instruction and research in any discipline should be organised as parts of an organic whole, they should be housed, as far as

possible, in the same building sharing the same lecture rooms, library and other facilities, and with the laboratories close to each other. This will bring the undergraduate, the postgraduate and the research students into daily contact with each other and with the members of the teaching staff, and thereby help to create and maintain an atmosphere of high scholarship and research. This is particularly valuable for the undergraduate students as they will be exposed from the beginning of their career to talk and discuss on recent advances in the subject and to the atmosphere of research.

#### COMMON TEACHING STAFF:

The undergraduate and the postgraduate courses should have a common teaching staff; and every qualified member should participate in teaching both. He will thus be able to keep abreast of modern developments in his field of specialisation. Otherwise, he will sink into a narrow groove by teaching more or less the same undergraduate courses year after year and get stale and deteriorate.

The seniormost members should take the juniormost classes as on account of their longer teaching and research experience, the students will be able to get a better understanding of the fundamentals of the subject. This is important. This contact with senior teachers and active research workers will have a beneficial influence



in inspiring the student to build himself up in his field.

In its report of 1959 on the Planning of the Indian Institute of Technology, Kanpur, the Survey Team of American Engineering Professors says ' unless the faculty member is a nationally known experienced specialist, it is desirable that he combines undergraduate teaching and research with his postgraduate program' (page 20). Further in the report (page 27), the Team says 'The advantages of close association of postgraduate and undergraduate instructions are:

a) promising undergraduate students may be guided into postgraduate work;

b) young engineering teachers have the examples of successful postgraduate teachers as a goal towards which to work;

c) the objectives of post-graduate work and research have a good influence in improving and vitalising the standards of undergraduate instruction at all levels'.

#### A HIGH LEVEL OF RESEARCH ACTIVITY ESSENTIAL:

Perhaps the most powerful means for bringing out and developing the latent originality and resourcefulness in the student is to maintain a high level of research activity in the department and in the institution. Research and development work should form an integral and even a dominant part of its daily work, and an atmosphere of bold thinking and experiment should pervade the place.

For this to be achieved, every teacher, from the senior most professor down to the newest recruit, should be an active research worker, working on his own or in association with a small group of not more than three or four persons including research students. He should devote at least as much time and attention to his research work as to his teaching duties. In a discussion before the Institution of Electrical Engineers, Prof. Tustin of the Department of Electrical Engineering of the Imperial College of Science and Technology, London, remarked 'it is essential in the long run, if we are not to see the standards of undergraduate teaching sink into squalid incompetence that a high level of research activities be maintained in such departments.' (1955, Vol. 102, part B, page 139). We, in India, should bear this constantly in mind.

The greatest part of the teachers' working day should be devoted to his scientific duties of teaching and research, the latter being atleast of equal importance with the former. He is no research worker or research guide who does not himself work in the laboratory, but claims to supervise and guide the work of others from his office room. In this connection, I cannot do better than to quote the following from the notable address that was presented to the Russian Academy of Sciences on 13th May 1943 by the great Russian Physicist, Academician P.L. Kapitza, Director of the Institute for Physical

Problems in Moscow.

'The organisation of the Institute and the conditions of work in it must be such that scientific workers are able to spend at least 80 per cent of their time either in the laboratory or on scientific work, diverting no more than 20 per cent of their time for social-political work. Only these conditions will enable scientific workers to do the laboratory work personally. Only if the scientist does the actual laboratory work himself and makes the experiments, even the most routine ones, with his own hands, can he achieve real results. A person who devotes some half hour to supervising scientific work cannot be a great scientist. I am convinced that the moment when even the greatest scientist ceases to work in the laboratory, he not only ceases to develop, but ceases to be a great scientist altogether .....

In the course of the discussion on Prof. Kapitza's address, the Chairman, Academician A.F. Joffe, another great Russian Scientist who died a little while ago, had this to say:

I welcome greatly the statement that every scientist must work himself and not only direct the work of others. This I consider really the most important prerequisite. Just as a painter cannot create a picture by merely telling his pupils where to put on green or red paint, so a scientist will come to nothing if he only

directs, without taking part in the work at first hand and without receiving first hand impressions from the actual progress of the work. This appears self-evident; yet the tendency of our scientific institutes is in the opposite direction. Exaggerating to some extent, I would say that as soon as a scientist has learned how to work, he ceases to work. A laboratory is put at his disposal; reports have to be written, plans must be prepared and a host of clerical work carried out. He issues instructions, he directs, and himself gives up scientific work.....'

These are words of wisdom which we in India should take to heart seriously and act accordingly, so that the available scientific and engineering talent does not get wasted in the desert sands of administrative duties, planning schedules and committee work. How many of us are 'committee scientists' and not laboratory scientists: A teacher's true work and professional standing lie in his ability to open up the minds and intellect of his students, the quality and volume of his research work and the calibre of the students and research workers that have grown out of his work and with his inspiration. These are of enduring value. It is unrealistic and of no consequence to judge a person by the position he holds, the salary he draws, the power and patronage he exercises, and the number of committees and conferences on which he sits. The attraction and glamour of these are ephemeral and without substance.

#### THE INFLUENCE OF A GREAT TEACHER:

How powerful, widespread and lasting can be the influence of a great teacher in bringing out the latent originality and resourcefulness in the pupil is amply illustrated by the examples of Helmholtz, Rutherford, Einstein, Appleton and Raman to mention but a few, taken at random. These great teachers attracted brilliant and gifted young scientists from far and near, who went to them like bees to honey. Together, they have changed the course of science and the affairs of men.

It is true that genius is rare; but there need not be any lack or shortage of enthusiasm, the spirit of dedication and the will to strive and to achieve. Such teacher will be no less successful in bringing out the best in their students.

#### IMPROVEMENTS IN UNDERGRADUATE EDUCATION:

Besides these, a great deal can be done to enable a student to obtain a good understanding of his subject and to make him resourceful and self-reliant by removing some of the obvious defects and drawbacks in the existing methods of teaching and examination. Consciously or unconsciously, they seek to get the student to learn, remember and reproduce a varied range of information, facts and data relating to the subjects he has to study. They do not help to develop initiative and the spirit of self help in the students; they have the opposite effect.

This is particularly true of the undergraduate courses. In the case of the postgraduate courses it is better.

#### THE BURDEN OF TOO MANY LECTURES:

Almost the first thing to do is to lighten the oppressive load of too many lectures a week and too many subjects to study at a time. 18, 20 or more lectures a week, on 9, 10 or more subjects by as many lecturers are not unusual. Nor is it unusual to have 4 lectures one after another on the same day, besides one more lecture or one or more tutorials in the afternoon - after the midday meal? This is an intolerable burden. After listening to only two lectures in succession, the receptivity of the student and his ability to concentrate get lowered; even note-taking becomes somewhat haphazard as he gets bored and listless. Continuous lecturing for 3 or 4 hours defeats the main purpose of education namely, that the learning of the subject must be done by the student's own effort, and that the function of the teacher is to guide, and help him in obtaining a good understanding of the subject and not stuff down his throat a mass of varied information and data. The teacher is not there 'to cover the syllabus', in the sense that he must deal in his lectures with every detail and derive every equation and formula. He is, there to stimulate interest in the subject and to explain the fundamentals of its theory and applications, and the important and difficult points in them. The rest must be left to the student.

Also, the students will gain greatly if instead of its being a monologue by the teacher, the lecture partakes of the nature of questions and answers in which all the students can participate. This is the only way by which the whole class will be alive, with every student taking keen and lively interest in the subject of the lecture. Such a discussion type of lecture helps him to get an excellent understanding of the subject; experimental demonstrations, and charts and models are always a great help. The 'talk and chalk' type of lecture which is unfortunately so universal is a poor and ineffective thing. For worse is the dictation of notes by the teacher; and this should be absolutely prohibited.

#### MAXIMUM NUMBER OF LECTURES:

The number of lectures per week is best kept down to a maximum of 15 or 16, and the number per day to 3. Lectures should be held in the cooler hours of the forenoon; lectures in the afternoon are best avoided as it is the sultriest part of the day and the students cannot be fresh and receptive after the midday meal.

Seminars and tutorials are very good devices to supplement the formal lectures, and these can be effective. They are helpful also in giving an opportunity to the student to gain some experience in expressing himself before a gathering of fellow professionals.

#### MAXIMUM NUMBER OF SUBJECTS:

To study at the same time 9 or 10 subjects is a heavy burden on the student. He will be better able to study if the number is kept down to not more than 6 or 7; he can then concentrate on them without having to devote his attention over too wide a field.

#### LABORATORY WORK:

The work that a student carries out in the laboratory is admittedly of crucial importance in understanding the theory and some, at least, of the practical applications of the subject. It is, therefore, essential that these experiments should be organised on a well thought out programme. Reliable and good instruments should be provided. The student too must come well prepared, so that he does not lose time in finding out what he has to do in the space of an afternoon of 3 hours. This preparation will be greatly facilitated if he is provided with appropriate laboratory notes prepared by the teaching staff. These will help the students in carrying out the experiments intelligently and with understanding. But they should not be so exhaustive as to deprive him of the opportunity to think out the important features that he should study in the experiments.

Just as in the case of lectures, the function of the teacher in the laboratory is to guide and help the student when he is in difficulty; otherwise, he should



leave him alone and not supervise his work all the time.  
WORKSHOP PRACTICE, DRAWING, ETC.:

What has been said under Laboratory Work applies equally in these cases.

#### PROJECT WORK:

Post-graduate courses include project work as an essential part of the course. Such project work may take one of several forms, including the design, construction and testing of a piece of apparatus or an instrument. Perhaps on account of the large numbers of students involved in undergraduate courses, project work has not till now formed a part of the students' work except in a few institutions. Such work undoubtedly gives considerable scope for the student to think and study for himself and exercise a measure of initiative. It also gives him a better knowledge of the application of the theory to practice.

#### THE EXAMINATION SYSTEM:

The method of evaluating the worth and performance of the student differs from country to country depending on its educational system and its tradition. There are differences between the American, the British, the French and the Central European methods of assessment. In India, the external examination system is almost universal; in this the teacher who has taught the subject and knows the student has virtually no say. While this system has its

good points, it is far from satisfactory in gauging the calibre of the student, this proper understanding of the subject and his ability to think on his own. His worth is evaluated almost entirely by the marks he gets in the single annual examination covering the portions of the approved syllabus prescribed for the year. Passing at this examination in the highest class and with the highest rank therefore becomes the sole object of the student; and as his future depends on his performance at this examination, he concentrates all his energy and attention on acquiring, remembering and reproducing such knowledge and information on which questions are most likely to be asked.

The defects and drawbacks of our examination system are well-known and have received considerable attention. In this connection, mention may be made of the 'Report of the Committee on the Indian Examinations Reform Project' (1959) of the team of ten educators who visited the U.S.A. in 1958, and 'Examinations in Indian Higher Education' 1959 by three American Educators. A number of recommendations have been made, and one can only hope that they will result in evolving a method which will judge better the worth of the student, and his understanding of his subject, instead of being virtually a test of his memory.

PRACTICAL TRAINING IN INDUSTRY:

This training during a part of the long vacations and or at the end of the college studies will help greatly

in opening the mind of the student to an aspect of engineering that an educational institution cannot provide. It is an essential complement to his studies in the college. For this to be effective, the authorities of the educational institution and of industry should cooperate in organising and operating a well thought out programme, preferably under the joint supervision of both.

Under such a programme, the student will have definite work to do on the shop floor, in the drawing and design office and in the test department. Such training will help the student to relate theory to practice, to obtain some understanding of industrial methods and of industrial workers. He thereby gains a measure of self-confidence and sense of proportion.

Industry too stands gain by this co-operating with the colleges in the education of engineers, in recruiting young engineers who already possess some appreciation of how industry works and who will, therefore, be able to take their work more readily. This point has been well brought out by Mr. V.R. Reddy, Assistant Educational Adviser, Ministry of Education, in his report on his recent visit to Universities and Engineering Colleges in U.S.A.

Such organised co-operative training for engineering college students does not exist in India. Industries in India, including state undertakings, hesitate to take

students for training except as observers. They cannot allow production to suffer; nor can they take risks with costly equipment and instruments by allowing raw young men not belonging to the establishment to handle them. They cannot also spare any of their staff to help the students.

The result is that the students have merely to observe while the work is going on. To do this throughout the day, and day after day for several weeks or months is exceedingly boring, and they feel that their time has been wasted, and get fed up. The whole thing is a farce and an infliction on the students.

In the interests of the country, it is time that the two sets of authorities get together and devise means by which practical training in Industry is made effective and fruitful to the students and to industry. This has been done in other countries; it can and should be achieved in India.

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## DISCUSSION:

R. SAMUEL remarked that of all the functions of the human mind, resourcefulness and creative thinking or originality were the most important. Emphasis should be more on thinking than on doing. What applied to an individual also applied to a community or to a nation. Recognition and appreciation of originality would go a long way in its development. He suggested that burden on such persons should be removed for more productive activity. He was of the opinion that association with people of ideas would help development of an individual. He urged that wherever originality was found a reward for the work done must be instituted. Instead of I.Q. tests for students he preferred O.Q. (Originality Quotient) tests.

R.P. ARTHUR remarked that if the seniormost members should take the juniormost classes, catering for the senior-students became a problem. He agreed that the seniormost members must have touch with the junior classes. The senior members do not mean the Professors alone but it included all those who have a certain period of service. He suggested that the raw recruits alone must not handle laboratory classes and that they should be supervised by senior members.

He wondered as to the permissible work load for a teacher. It was given in the paper as 15 or 16 hours per

week. He wanted to know whether it included laboratory, drawing and tutorials. He did not agree that 15 or 16 hours should be all lectures. According to him the lectures may be limited to 8 or so and the remaining time must be spent for laboratory and tutorial work.

D. KAMALAKANNAN remarked that the author had said that portions or certain subjects must be completed and examinations conducted immediately without making the students wait for over a year or longer. He said that unless the University changed their system, this would be impossible. He suggested that the Board of studies could make the recommendations to the University.

Md. SULAIMAN remarked that there was a lot of disparity in marking among the different colleges if it was entirely left to internal examination, and added that unless the integrity was improved, it would be impossible to replace the present external examination system.

K.S.G. DOSS remarked that the examination system could be slightly modified. He said that the subjects could be taught in the form of questions and standard answers to be found by students from the standard text books. According to him if the question paper was set from among these standard questions, and if valuation was done by two examiners, internal examination system might be instituted.

## DEVELOPMENT OF RESOURCEFULNESS AND ORIGINALITY

K.S.G. DOSS

### INTRODUCTION:

I thank the Director of Technical Education and Co-ordinator, for having thought of asking me to give this lecture. I consider it a great honour, to have been asked to speak to this enlightened audience on this subject. I am to speak on 'The Development of Resourcefulness and Originality'. While it is a fact that I accepted this task without any hesitation to give a lecture on this subject, I find on deeper reflection that this field would have been more competently dealt with by an applied psychologist. What I am going to speak, therefore, is not a comprehensive treatment of this subject but rather a few reflections on some aspects of the subject as far as they relate to my own experiences. I shall first take up 'Originality' and refer to 'Resourcefulness' in passing, later.

### WHAT IS ORIGINALITY?

Originality or creativity refers to the capacity to discover something intrinsically new, something like a bolt from the blue and a contribution which transcends prior experience. Creativity is of importance in the whole spectrum of human activities, be it in the field of art, science, technology or philosophy. You see a new life in the original painting or sculpture; you find a new delight in an original exposition of music or dance.

You find a new thrill by reading through an original novel. ~~An original~~ discovery in the field of science or technology often leads to a revolution in theories or techniques and causes great advances in the field, which may tremendously alter even the course of human history.

In the immediate context of our country's development, I would consider creativity in science and technology, as most important since it not only joins art and philosophy in the celebration of human spirit, but also takes the most prominent part in the industrial development of our country and ranks equal in importance to productivity and perhaps very soon takes even a higher place than simple productivity.

#### IMPORTANCE OF ORIGINALITY IN NEW DISCOVERIES:

Being highly skilled and erudite does not necessarily mean that one is highly creative even potentially. This becomes clear when we study the working of the creative intellect. It is often stated that creativity is the outcome of sheer intense intellectual effort. It is thought that the whole effort begins in clarity and order and systematic understanding and proceeds in logical advances and under pressure of will into the foreseen or partially foreseen structure of a system. This is perhaps true in some of the interesting developments, as example of which I could mention the classical treatise of Gibbs on thermodynamics. Amongst the living scientists of this type, I may mention Carl Wagner in the field of solid state



electrochemistry. For them the question of speculation does not appeal and the whole thinking is precise and subject to control of unerring logic and mathematical methods and thermodynamics. When I met Carl Wagner in Germany last and discussed his work, I asked him one question relating to solid state electrochemistry and that was as to, what could be the probable substances which would give very good photo-conductive effects. He straightly replied that it was not his field and he could not answer the question. I told him that I knew that he did not do any photoconduction work but in view of his vast experiences of the behaviour of a number of solid electrolyte systems and solid semiconductor systems he could perhaps make a guess as to which would give the best results. His immediate reaction was, 'No guesses! You can see from my papers that my approach is not a speculative one'.

Whereas this type of development of science does occur here and there, most of the important advances take place in a different way altogether. Creative work often starts with a heavy labour, a seemingly fruitless struggle for insight into some area of obscurity. There is a good degree of confusion at start. There is no very precise foresight. There is a multitude of shifting images and ideas and the course of thinking gets progressively settled. This is often followed by a quiescence,

a period of incubation, may be a gestation or an unconscious creation at the end of which there is a sudden emergence of a new insight in the form of spontaneous flash of lightning in the utter darkness, a flash - which represents an unpremeditated development - which gives a feeling of conviction and certainty and also a high aesthetic gratification. The beauty in scientific discovery is not just that strikes the senses - it is a new profounder beauty in the form of a harmonious order of the parts underneath the apparent incoherence and disorder - which a pure intelligence can grasp. This is next followed by further labour for verification, reappraisal and revision and a proper presentation. The creative discipline therefore appears to alternate between madness and method - mindless wildness on one side that looks irrelevant to the methods produced; on the other side deliberate labour, so painstaking (or is it pleasure taking?) that it might itself be enough to produce anything - no matter how wonderful. This explains the reason why creativity has been identified as 'All inspiration' at the one extreme and 'All labour' on the other.

I would like to refer to my own small experience in this connection. While we were investigating the mechanism of alternating current electrolysis, it occurred to us that a small rectification may occur at the reversible electrodes. The very first experiment confirmed our

expectation. When we tried to work out the quantitative theory however, we were confronted by a difficult mathematical problem. We referred it to a mathematician who only pronounced that the expressions were not explicitly integrable and therefore, there was no possibility of making any progress in the formulation. This disappointed us very much indeed and it was after several weeks at late night when I got awakened, it occurred to me that it should be possible to work out the formulations for small voltage. I got up immediately and started working on it. By the morning the formulation was ready. The results indicated that the phenomenon was much more important than what we first imagined and was of great fundamental significance. Today, this phenomenon referred to as 'Faradaic Rectification' has been found extremely useful as a research tool in electrochemistry for investigating fast reactions for which there is no alternative technique available at all at present. But for this discovery it would have been impossible to measure the speed of fast reactions.

If I could cite another example again from my own experience, I would mention the discovery of activated accumulation. When I was working out the cause of the variation of surface tension with time exhibited by dye stuff solutions, it occurred to me (it was a big mistake) that there was perhaps no variation of surface tension but only there was variation of contact angles. To frame

this in a conclusive way, I improvised a film balance (since no such balance was available at the market for purchase either in India or abroad). The first experiment itself demonstrated that there was a variation and that it was reproducible. This set us thinking as to the causes. This was particularly tormenting to me because the normal test applied in the film balance apparently showed a great contamination of the surface even when the greatest precautions were taken. It was again sometime in the night it occurred to me that the 'contamination' was nothing but the solute molecules themselves coming to the surface. This gave the necessary starting point for proper formulation of the cause of variation of surface tension with time which completely explained all the facts about this phenomenon, which had remained mysterious for over fifty years.

#### RELATION OF CREATIVITY TO OTHER PATTERNS OF BEHAVIOUR:

I do not wish to go into the question of correlation of creativity with any signs or pattern of discernible symptoms of the creative worker. Often a creative artist or scientist is associated with a certain amount of eccentricity, particularly with regard to hair style or dress or perhaps human relations. It is not necessary to give any specific examples as we are all intimately aware of the appearance of many brilliant South Indian original exponents of music. Amongst the scientists I may only ask you to look at the picture of the great Einstein.

It would however be ridiculous to think of developing eccentricity with a view to acquire creativity. I would also add similarly that whereas some of the creative artists were addicted to drugs, alcohol and other stimulants, the opposite is not true and addicts mostly do not have any creativity.

#### MEASURES FOR DEVELOPING ORIGINALITY:

I would now like to briefly refer to the measures that we can take for the development of creativity. Whereas the greatest of the creative geniuses need no help from us at all, a deliberate effort in the direction of development of creativity in a group of individuals could be extremely helpful in narrowing the gap between an individual's innate creative talent and his lesser actual creative power. This needs a little analysis of 'creative thinking'. As I have already pointed out earlier, the creativity consists in getting something new and often by a flash which occurs by mind, heart, intellect and emotion, all going simultaneously into action. Mind does not move in security from the old configurations of insight to the new ones extending and enlarging grounds of certainty as in a march to a new territory adjacent to the old. But, often, mind advances where no grounds exist and creates a new one under its foot. In order to invent, therefore, it is necessary to think aside. To concentrate on the old and irrelevant configurations would mean restricting the movement of the mind.

## EMOTIONAL AND CULTURAL FACTORS:

First I would consider the emotional and cultural factors which are blocks to creative thinking. The most important factor is perhaps the want of motive power which is got by the readiness to accept challenge from the problems facing us. I can give one or two examples of this from my own small experience. I once saw a prodigy doing multiplication of five figure digits mentally. That was when I had just completed the SSLC examination. Having nothing else to do, I thought I must discover how this prodigy did that mentally. I felt he might have a secret formula and so sat down to discover the formula. In fact this was a foolish thing to aim at, since many great intellectuals would have aimed at this and since nothing had come through so far, it was very unlikely indeed that an ordinary person could succeed in finding out a new formula. Nevertheless this effort for about two to three hours bore one result that I discovered a new method of squaring even six figure numbers in two lines. It was a consolation to me that the same method was described by a physicist in Current Science more than 15 years later. Similarly, it was in the P.U.C. class that one of my junior friends challenged me to balance a chemical equation, which I failed to do. I was a little disgusted by the humiliation that it should be so difficult to work out the balanced equation and so sat down to find out a

general method of doing it. The very first attempt was a success by putting X, Y, Z etc., for the unknown variables and working out the various equations. It was possible to show that any equation can be balanced by a pure algebraic method. It was again comforting to see that this method was already described in an old edition of Walkers Physical Chemistry and was reported as a new discovery in the Journal of Chemical Education by many American teachers again and again several years later in the thirties. One other case I would like to quote was in my first year B.Sc., Class and this time the challenge came from an Engineering student-friend of mine. When we met after a week's work of our respective colleges in the first year, we had a little satirical exchange of words when he mentioned with great pride that he was being taught calculus whereas in the science degree course I did not have that privilege. I immediately challenged him and said that without the help of calculus, I would solve any problem that he does with calculus. He straight-away gave the following problem:

A body moves according to the equation:

$$S = 20 + 21t + 22t^2 + 23t^3$$

and asked me to calculate the speed at the end of 100 secs. I took down the problem carefully on paper, spent a few hours and worked out the answer not only for 100 sec., but a more general solution. Willingness to accept challenge is one of the most important things to be cultivated.

One should have full confidence in oneself that one can find out something new and should not be subject to a pessimistic outlook. It is, therefore, desirable to emphasise some aspects of the History of Science, how the most intelligent scientists are not necessarily the most creative.

Next important aspect is to avoid too much towards conformity to old ideas. Too much belief in the old ideas as being unassailable is the sure way of avoiding original thinking. Too much of reliance on authority is the real danger for creativity although in very well-known fields and in clear regions where the high intellectuals have already perfected the whole field, it would be somewhat difficult to find out new ideas. One should also be careful not to go to the extent of doubting irrefutable laws of nature or well-known relationships in mathematics and thermodynamics. Such an attitude would be disastrous.

Then again excessive faith in precise reasoning or logic is also often a handicap for original thinking. The difficulty that comes up is that unless every information is available for proper logical reasoning, the mind refuses to move further. Similarly fear of making mistakes should not be there as also the fear of looking foolish. The required concepts, facts and the techniques are not often available and the situation requires substitution of these by scientific intuition. Wild thinking



should therefore be encouraged and even appreciated; any needed control should be gently suggested without ridiculing the young thinker.

An urge must be there to find out something new and not to feel satisfied with just understanding what has been already achieved by others. The novelty may be with regard to a new aspect observed in any old phenomenon or a new concept relating to an old formulation.

#### PERCEPTUAL FACTORS:

The second group of factors which block creativity are related to perception. For instance, there may be too much rigidity in looking at the problem and narrowing too much. I would cite an example. It was in a Mental Hospital that on a particular day the main supply pump for water tank failed and there was a little chaos in the hospital. When the Chief Medical Officer posed the problem to the Engineer later, the latter straightaway suggested avoiding the pump altogether and having a direct pipeline between the overhead tank of the Hospital and the main feed tank of the city. Calculations were undertaken and the result came out to be that they had to lay a 7 mile pipe-line having a diameter of more than 18 inches just to supply a few thousand gallons of water per day. I do not know if this was ultimately given effect to as I have not ascertained it from them, but obviously a better alternative would have been possible if the problem was not viewed in such a narrow way. It is a good practice, whenever a problem is thought

of, to systematically examine every solution irrespective of its merit, and defer judgment with regard to the evaluation till after the solutions have been thought of.

The second perceptual factor that comes up is the failure to use all senses while observing. Careful observation of phenomena has helped many times to achieve original discoveries. Discovery of argon by Ramsay can be an example to illustrate this. His careful study of the earlier literature that a small bubble of gas remained unreacted when the air was sparked with gases of oxygen with caustic alkali led him to an elaborate and precise experimentation and to make the discovery of argon as a constituent of the atmosphere.

The third factor which is important is the background knowledge and thinking capacity without which a proper development of even a flash becomes difficult.

It is important to go to the frontier while making efforts at originality. Any creative thinking in a field well behind the present position of development may lead to just discovering something already known and this should be a waste of effort and intuition.

I do not believe that this needs any elaborate illustration. I would however, refer to the cases that I have already cited earlier, viz., that of solving the differential equation without the use of calculus and the new method of squaring of a number of examples wherein efforts were there but not at the frontier and

naturally the results were of trivial importance from the point of view of novelty. Therefore, there is only one place to be in the research scene, i.e. the front. Furthermore if one is on the frontier, the time spent over reading is a minimum and all the time is available for thinking.

Furthermore, it is desirable to get a physical picture of every mathematical derivation as far as possible. A correct and precise picturing helps in working out the solutions without the arduous process of mathematical formulation. As an example, I may add that I was confronted with a problem of working out the mechanism of electro reduction of pyruvic acid. On going through the mathematical formulation, which involved Laplace Transformations, I could evolve an equivalent, simple and general procedure based on physical concepts. This was extremely helpful in formulating the results of the different mechanisms and it was possible thereby to show that our new mechanism was more successful in interpreting the experimental results than the one suggested by the authors of the data.

I may perhaps state that in my experience the one person who has the unexcelled genius in this direction is Professor C.V. Raman. I was very much impressed by his original exposition of Maxwell's electromagnetic wave equations by making use of two fingers. I would also like to take this opportunity of giving an account

of the discovery that he made by this technique, when I was a eye witness. This was more than 30 years back. I was attending a colloquium organised by Professor Raman in his department at which Dr. Parthasarathy, the late Deputy Director of National Physical Laboratory, Delhi gave an account of the theories as known at that time, of diffraction of light waves by ultrasonic waves.

Dr. Parthasarathy in the course of the exposition had completely covered the two big black boards with a large number of mathematical formulations. At the end of the lecture Dr. Raman asked the lecturer to resume his seat, went to the blackboard and drew two diagonal lines on the two black boards and exclaimed 'It is all wrong!'. He continued 'Look here, the whole thing is very simple. Look at this. Here is the crystal vibrating and emitting ultrasonic waves which form a stationary pattern. So you find here successive layers of rarefaction and compression piled up. See what happens when a plane wave (of light) traverses through this medium. Because of the rarefaction and compressions there are regions of regularly varying refractory indexes. The plane wave therefore gets corrugated. Every corrugation represents an image. You see what happens if the plane wave of light is incident obliquely. There would be an asymmetry in the corrugations and therefore in the distribution of images in the vertical plane'. Addressing the mathematician (Mr. Nagendranath) he said

'You work it out and you will get it; I assure you'. After three days came out the formulation of Raman-Nath theory, completely confirming his predictions.

It may not be out of place to refer to the relationship of age to originality. There is a lot of controversy as to whether originality comes down with advanced age. It is known however, that the past experience of failures and successes in research should help in developing better methods of analysis of problems as well as in the selection of fields, problems and techniques. This would definitely give a vantage position to the aged person as compared with what he was when he was young. It is not impossible however that in particular individuals senility may set in and the thinking faculty may get dim and conservatism may develop leading to single track thinking. But a careful analysis of the position all over the world and in India in particular shows that there is a much more important circumstance which lowers creativity as one gets a little older. Once a scientific worker gets some good achievements to his credit, he often is put into responsible administrative positions and is burdened with noncreative activities and responsibilities. He being accustomed to take up any work extremely seriously with a view to finding out the best solution for the problems confronted, takes up these activities also with the same vigour. The result is that he could find no time for creative thinking in his own scientific field.

The following is representative of the "life of the Professors and Directors of Research:

" A Professor's life now-a-days is a rat-race of business and activity, managing contracts and projects, guiding teams of assistants, bossing crews of technicians, making numerous trips, sitting on committees, sanctioning leaves, loan advances, inaugurating scientific, arts, philosophical and other associations, hearing complaints and grievances from staff and outside bodies, replying representations, writing D.Os to Central authorities, public and industry, writing confidential reports, creating posts, making selections, fighting for budget allotments, modifying policies, allotting finances, residential quarters, dealing with the scheming of unscrupulous, mischievous and powerful individuals amongst the staff etc.,

It is not only a question of not finding time physically to think of research problems but it is the loading of the brain with other human problems that completely inhibits creative thinking. This poses a serious problem today and most of our creative thinkers are obliged to take up administrative posts partly on account of financial and status considerations and partly because of the fear lest any other administrator put in that important position would completely create barriers for one's own creative work.

I would conclude this aspect by quoting the following,

which I always consider as very much worth remembering:

"When you think you have a good idea, be swift with the swiftness of a tigress and spring on its neck and never leave it go until you had your fill! Fling away the carcass when you have done with and move forward and never look back". TAGORE.

Coming to resourcefulness, I would only say that it is originality at the domestic frontier.. Novelty of the ideas evolved need be only with reference to the local environment. Accordingly, one may draw considerably from one's own past experiences as well as from other's experiences. Resourcefulness sometimes also is applied to less serious matters such as a game of chess, crossword puzzles and so on.

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## DISCUSSION:

S. SANKARALINGAM remarked that there might be difficulties in applying the idea expressed by Doss to our daily work of teaching students. He wanted our thinking to be directed to produce that creative ability in the student. He urged that the students must be made to think in a rational way. He suggested that it would be better to prepare the student for the nature of work he would have to do later in his life and that he must be trained to think for himself.

E.C. CHANDRASEKHARAN remarked that a research worker should have the sincerity of purpose and tenacity to achieve what he was working at. According to him, it was better to make a note of all ideas however absurd they might be. He suggested that a Professor directing research, should allow the students to work and find out the materials available for himself and not impose everything in the beginning itself.

J.C. KULANDAISWAMY remarked that generally we are accustomed to thinking that originality is inborn. The European view is also more or less the same. The Americans think that given the proper background, almost anything can be taught. With proper environment and methods of instruction, it is possible to develop in individuals creative ability and resourcefulness. It is true that Einstein and Bernard Shaw are born and not made. But in the case of lesser inventors and thinkers, much could be made by systematic effort.



M.N. NARAYANA RAO remarked that the creative genius must be developed in a person at an early age itself when they were children. He felt that the inquisitive child must not be checked but encouraged. Meditation was necessary for proper development.

R. SAMUEL remarked that a problem must be viewed as a whole and not piece meal. He said that suggestions given must be accepted and received. He felt that unless there was a receptive group, the enthusiasm of the research worker might be damped.

K.S.G. DOSS in his summing up, remarked that problem - solving groups might be set up in each section of Engineering. Enforcing a short period of relaxation among the students would help to carry through heavy dosages of lecture. He felt that research in India was difficult. But he was of the opinion that resourcefulness could play considerable part. He suggested that if we could find alternatives and substitutes for equipment not available in India, it would help the nation and the individual considerably.

He said that an administrator went by rules and regulations. Hence according to him he might not appreciate the demands. But a scientist as an administrator might also prove dangerous as he might try to take all the credit for the work done by his subordinates. Due recognition to the right persons might not reach them. He felt that there are both advantages and disadvantages in either case. He suggested that a history of the discoveries made would help in the training of a young thinker.

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## FUNDAMENTAL SCIENCES AND TECHNOLOGY

ALLADI RAMAKRISHNAN

It is both impertinent and embarrassing for me to speak to a group of enlightened engineers about the role of fundamental sciences in technology. This is now accepted almost as axiomatic and the study of basic sciences is today an integral part of the curriculum in technology. However, I feel there is a necessity to emphasise three aspects in the inter-relationship of pure and applied sciences with particular reference to advanced education in India.

What is treated as an axiom is that the mathematical sciences are useful and necessary tools; but what may not be equally obvious is that the pursuit of fundamental sciences for its own sake in an Endeavour which almost guarantees the growth of technology. I can best express this through the inimitable words of one of the greatest physicists of the world today Professor Julian Schwinger of Harvard:

"The scientific level of any period is epitomized by the current attitude toward the fundamental properties of matter. The world view of the physicist sets the style of the technology and the culture of the society, and gives direction to future progress" )

Thus, if the growth of technology depends on the moving frontier of fundamental sciences, this can be achieved not by treating basic sciences as tools, but as the primary aim of those who are devoted to their development. This has been adequately realised in the United States which has sponsored the simultaneous growth of fundamental and applied sciences. In fact, in India, where a desire for economic development has become not only a necessity but almost an obsession with the planners and administrators, there is a great danger of treating fundamental sciences as a tool, albeit necessary, yet only an appendage to applied technology. This shortsighted attitude will lead to a stifling of initiative in the creative sciences and may ultimately retard the technological development in the country.

There is a second significant feature in the relationship between pure and applied sciences. In the growth of human knowledge, it is impossible to predict whether theoretical or experimental work precedes the other in any stage of development. There are as many examples of discoveries of experimental work being stimulated by theoretical predictions as there are experimental discoveries leading to new theories. It was Dirac's logical interpretation of negative energy states that preceded Anderson's discovery of the positron. On the other hand, the experimental discovery of strange particles stimulated the Gell-Mann-Nishijima

relation which burgeoned into the beautiful  $SU(3)$ -symmetry. This has been best expressed by Murray Gell-Mann of California as follows:

"There is the really exciting prospect of total surprises, things completely outside our experience, which our presentday theoretical language is inadequate to describe. For the last few years, theoreticians have been doing pretty well. Fifteen years ago they were in miserable repute after spending ten years describing the muon by a theory of the pion. The experimental discovery of strange particles took them totally by surprise, just like the existence of the muon. I think another reversal of the positions of experimentalists and theorists is about due now. The strain has been accumulating for 15 years; the shock should come fairly soon"<sup>2</sup>

Thus, to the experimenter the theorist should be a companion and co-worker in the high endeavour of understanding and mastering the forces of nature, and not just a useful assistant providing him with the necessary tools.

The third aspect of this relationship is that it is impossible to foresee the domain of the applicability of any advance in fundamental sciences. A gravitational theorist would be convinced of the validity of the relation  $E = M_c^2$  purely through the principles of

Lorentz invariance while a nuclear theorist would use it for estimating the energy released in nuclear fission. A theoretical physicist will not be surprised if a new gifted entrant to elementary particle physics, unacquainted with gravitational laws, rediscovers the principle of special relativity purely by the study of hyperfine structure of spectral lines. The two frontiers in the study of the basic laws of natural sciences, that of the very large, (the cosmos) and that of the very small (elementary particles) seem to merge with our increased understanding of such laws. The same situation seems to be true as regards the domains of pure and applied sciences.

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- i) Nature of Matter: 'Purposes of High Energy Physics' (Brookhaven Collection of articles, 1964) Science Vol. 147, pp.1548-1556 at p.1554.
- ii) 'Particles and Principles' by Murray Gell-Mann, 'Physics today' November 1964, pp. 22-28 at p.28.

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## DISCUSSION:

V.N. SUJEER warned that the subject of applied sciences like quantum-mechanics, electro-magnetism etc. would be so fascinating that there was a danger of the technologist becoming a pure scientist. He wanted this danger to be avoided. He also said that we were at present lagging in the Technological advancement compared to other countries. He wanted this to be changed so that we could also make some original contribution.

A. RAMAKRISHNAN replied that the theoretician could meet the experimenter and vice-versa. He remarked that seminars on co-operative basis would help to avoid the danger of technologist becoming a pure scientist. According to him, we have gifted Mathematicians and scientists. But he was of the opinion that they in India were not meeting together to take advantage of the advance knowledge of experts and use it for development. He was certain that if this was done, we would not lag behind but push forward.

H.S. SHIVASAMY remarked that the standard of basic sciences for engineering students appeared to have gone down with the result we were thinking of a two year P.U.C. He felt that it would be better if a student was given a high quantum of Mathematics and basic sciences before he entered the Engineering College.

V.C. KULANDAISWAMY said that the speaker had remarked that Engineers look upon Mathematics as a tool. According

to him Mathematics is the foundation for engineering. A good hydrologist must be able to understand the meteorologists, hydro-meteorologists, geo-hydrologist and geologists; unless the hydrologist had a good knowledge of Mathematics and pure sciences, he would not be good in his field. He was of the opinion that engineering was an applied science and an Engineer translated the achievements of pure science into those of engineering for human use. He also felt that apart from pure Mathematicians, there should be a few practical mathematicians who could appreciate the problems of the engineer and could give solutions to them.

NARAYAN RAO felt that we should cater to the demands of our Industry which did not need highly qualified scientists. According to him we could leave pure science as an elective and fulfill the needs of the industry.

W.J. FEILREISEN traced the history of Mathematics in Engineering curriculum in U.S.A. for the last 20 years. Mathematics portion in the Engineering curriculum stopped with the second year sophomore. Later the Engineering courses started and there was option to deviate from further use of mathematics. In 1952 the ECPD made certain changes to impart larger quantum of Mathematics into the Engineering curriculum. In 1962 a committee again revised the requirements of Mathematics and basic sciences. A number of schools teach calculus as an

elective. Advanced courses such as probability, linear partial differential equations, statistical quality control etc. are offered for those who would go for advanced degrees in Engineering. According to him in basic sciences also, a similar change had occurred. He said that what were covered in the colleges in previous years were now being covered in high schools and that topics such as theory of relativity, nuclear physics etc. have been introduced. He further said that so also in chemistry, stress had been laid on the fundamental properties of matter. According to him at the University of Wisconsin, liaison between the Engineering and Mathematics faculties did not exist. He felt that to an engineer, Mathematics was a tool. He suggested that he must recognise the physical concepts of the mathematical equations. This should be the end of an Engineer's knowledge of Mathematics. He felt that in India, it would be best if the students learn more of Mathematics so that it would be of greater use to them in bridging the gap between India and advanced countries.

A. Ramakrishnan remarked that an Engineer or a technologist should aim only at excellence in his field. But he felt that he must work in co-operation with a scientist so that it would result in greater benefits. He suggested that developing institutions should contain experts from each field - a complete spectrum. He felt that courses must be offered only by experts of that field and the style should be set by them.

The chairman remarked that great teachers in various fields could help to understand the experts in those fields.



## THE ROLE OF HUMANITIES IN ENGINEERING EDUCATION

R. KRISHNAMURTHY

I thank the organisers of the 'Summer School for Teachers in Engineering Institutions' for inviting me to speak to-day on 'Humanities in Engineering Education' before this gathering of Engineering Teachers. This is the second Summer School of its kind, the first being held this time last year at Coimbatore under the aegis of my esteemed friend, Sri G.R.Damodaran, Principal of the P.S.G. College of Technology, Coimbatore. The value of such Seminars and Summer Schools is well-known. They bring together a number of people interested in the same or allied subjects, and enable them to establish personal contacts and to discuss problems of special interest. In such discussions, doubts are raised and answered, light is thrown on various obscure points, and the participants learn a great deal by these (formal and informal) contacts. This particular Summer School has been planned to last a fortnight. I am sure that at the end of the session when the participants go back home they will feel that they have benefitted immensely by these lectures and discussions.

The need for fully-equipped engineers is recognised all over and particularly so in a developing country like India. The Union Government in India is

seized of the problem and has started within the last 15 years five higher technological Institutes of National importance, one of them being the Indian Institute of Technology, Madras. The various State Governments are, as it were, vying with one another in starting new Engineering Colleges and in strengthening and upgrading the already existing ones. For example, in the State of Madras, there is an Engineering College at the Annamalai University. There is the Madras Institute of Technology, Chromepet. In addition to the above, there are eight Engineering Colleges affiliated to the Madras University. They are:

1. Engineering College, Guindy
2. A.C. College of Technology, Guindy
3. P.S.G. College of Technology, Coimbatore
4. Coimbatore Institute of Technology, Coimbatore
5. Government College of Technology, Coimbatore
6. College of Engineering and Technology,  
Karaikudi
7. Regional Engineering College, Tiruchirappalli
- and 8. Theagarajar College of Engineering, Madurai.

A similar expansion in Engineering education is seen in the neighbouring States of Andhra, Karnataka and Kerala. In other States of India also, the same desire to start new Engineering Colleges and to increase the output of Engineering Graduates are very much in evidence.

I shall now attempt a brief survey of the provision made for the study of the Humanities in the Engineering and Technological Colleges within the Madras State. In the I.I.T., Madras, the following subjects are taught: English, German, History and Culture, Principles of Economics, Industrial Management including Industrial Psychology and Human Relations. The course is spread over all the five years, and about 8 per cent - 9 per cent of the total contact hours is set apart for the study of the Humanities.

In the Engineering Colleges affiliated to the Madras University, English, Humanities and Industrial Management have to be studied by every student. Under the heading 'Humanities' are included Social Economics, Problems of Indian Economics and Industrial Psychology, Human Relations and Industrial Management. The Engineering College of the Annamalai University provides for special training in English during the first year, and short courses on the Humanities during the fourth and fifth years.

From what has been mentioned above, it is clear that the I.I.T., Madras, makes larger provision for the study of the Humanities than the Engineering Colleges affiliated to the Madras University or the Engineering College attached to the Annamalai University. But there are certain basic subjects in the Humanities which are

emphasised in every one of them. It may be assumed that the Engineering Colleges in the other States of India have by and large the same pattern, and that they give about the same importance to the Humanities in their syllabi.

Not many years ago, in India, Engineering Colleges made no provision whatever in their curriculum for the study of the Humanities. It was argued in those days that the Engineering Course is a specialised course, that the students had studied enough Humanities subjects before they joined the course, and that it would be a waste of time to make them study any more Humanities subjects. The same opinion existed in a number of American Universities also in the twenties of this Century. But during the last 40 years, people have become increasingly aware, both in American and Indian Universities, of the consequences of excessive specialisation in Technology. Such training will necessarily be one-sided. Slowly opinion has crystalised within the last 25 years that students of Engineering and Technology should compulsorily receive some training in the Humanities.

A word of caution has to be uttered at this stage. The quantum of knowledge that can be given in the Humanities in an Engineering College or Technological Institute will be necessarily limited. In these Institutions the primary subjects of study will be the Sciences - both the Basic Sciences and the Applied sciences. The humanities will occupy a subordinate

place in the curricula of studies. They can never overshadow the study of the Sciences. While no hard and fast rule can be laid down, the suggestion may be made that 7% to 10% of the contact hours during the entire period might be set apart for the Humanities.

All of us realise how the study of the Sciences satisfies the needs of individuals and the Community by enlarging their understanding of the material world. The volume of scientific knowledge that is available to man-kind is increasing day by day and every available minute of time will be required for mastering them. At the same time, it has to be recognised that while specialisation is necessary, it can never be an end in itself. The purpose of Education is not to produce human robots. The specialising student has also to develop his mental powers, his critical faculty and his imaginative vision. It is beside the point to argue that the study of the Humanities will take away some of the valuable time which would otherwise be available for the study of the Sciences.

An attempt may now be made to assess how the different subjects in what we generally call the Humanities and social sciences appeal to us. The classics place before us the achievements of the great minds of old in the various branches of literature. It may be the immortal epics of Homer and Virgil, the Mahabharata and the Ramayana, the great plays of Shakespeare, the poems of Milton or the inspired writings of Kalidasa.

Some training should, if possible, be also imparted in the appreciation of the Fine Arts - Music, Drama, Dancing, Painting, Sculpture and Architecture. Who that has eyes to see and ears to hear can remain unmoved when he sees some of the masterpieces of painting, sculpture or architecture in the world, or hears the inspired melodies of some of our greatest musicians?

Philosophy brings us into contact with the thoughts of eminent thinkers - ancient and modern - on the great intellectual and moral problems that mankind has faced in the past, is facing now, and will be facing hereafter. The social sciences help us to understand our own behaviour and that of others within the institutions which we have made for ourselves. They make us aware of the factors determining the progress of History, and the social forces which are active in the world. Social psychology deals with the socialisation of the individual and the development of his personality in the particular social setting. Logic helps people to think soundly, to judge competently, and to acquire a knowledge of those basic principles which contribute to mental growth and mental health. The study of Economics is so necessary to the individual and the community in this complex world of ours. Some knowledge of the legal aspects of business and of industrial legislation may also be considered to be necessary for the engineer - administrator.

Management studies are acquiring great importance in these days, and have already become a special branch of study.

Humanities help the individual to achieve a mature understanding of his cultural heritage, an enlarged appreciation of values, and a philosophy of life adequate to modern needs. They aim at stimulation rather than specialisation, at perspective and value rather than encyclopaedic knowledge. They also help in the growth of a capacity to communicate effectively, to understand one's cultural and social environment, and to develop aesthetic appreciation of all that is great and beautiful. They enable us to become good citizens who will discharge properly their functions to the community.

Life in the modern world has become complex. The professional man, the engineer, the technologist is not merely a component part of the machinery of a large workshop or factory. In the practice of his profession, he has to come in contact with human beings. He should have an understanding of the community which he is called upon to serve. He has to work with people who are his technical equals or subordinates. In his relationship with them, he has to put forth his best: and for this, some knowledge of industrial psychology is very necessary: He should also aim at an all-round development of his personality. In his desire to acquire technical

efficiency - and this is certainly the duty of the technologists - he should not neglect general culture. Of what use is specialisation to the Engineer, it may well be asked, if he loses his humanity and his humanism? Humanities alone will train him to take decisions on social, civil and political issues, and to help in the constructive participation with his fellowmen for the realisation of a richer, fuller and happier life.

The Massachusetts Institute of Technology, which is the model for many modern technological Institutes, expects every student to take some lectures on English Literature, and one or more foreign languages and some fine arts. One distinguished President of this Institute declared on a recent occasion "The Institute trains for life and for citizenship, as well as for a career. The teaching staff seeks to cultivate in each student a strong character, high ideals as well as a keen intellect". These are wise words. Let us remember them when we are framing the curricula of studies for our Engineering Colleges.

So far, an attempt has been made to show how the study of the humanities will be useful to the technologist, and how it will make him a better citizen. This is one aspect of the problem. But in a few exceptional cases, even among technologists, the study of the Humanities may become an end in itself. It will open out vistas



before the specialist, which he would not have dreamt of. The Delectable Land is always there for him to enter and enjoy. That is the justification for the Humanities being considered to be one of the intellectual disciplines for all people. No education will be complete even in a technological Institute unless the student has learnt to experience some of the thrills and joys which the Humanities alone can give.

To sum up, the technologist requires a basic training in the Humanities. In the nature of things, such a training cannot be of an advanced standard. It may be the bare essentials, the fundamentals of the subjects concerned. Care should however, be taken that it does not become a mere smattering or something superficial. The Humanities form a complement to the Sciences (Basic and Applied). There is no conflict between them. It is the duty of educationists to arrange a programme of work in our Engineering Institutions which will be a synthesis of the Technological and the cultural elements in education, special prominence being given of course to the technological part of it.

## DISCUSSION:

The chairman remarked that in U.S.A., the fact that students should learn more of humanities, had been recognised and due importance was being given.

P.S. KRISHNAMURTHY: said that Prof. Krishnamurthy has pleaded for an increase of humanities syllabus in Engineering curriculum. But generally the students devote very little time to the study of humanities. He felt that the choices of text books must be done properly.

C.T. SREERAMULU: remarked that from a review of the time spent on non-technical subjects in Indian and American Universities, it was found that allocation of contact hours for technical and non-technical subjects was as given in the following tabular statement.

	<u>Indian</u>	<u>American</u>
Total contact hours	6120	2500
Non-technical Hours	365	700
Technical hours	5765	1800

He said that this indicated a low allocation of time for non-technical subjects under which humanities came in. Hence he felt that an increase in humanities syllabus was warranted. According to E.C. CHANDRASEKARAN a certain amount of legal knowledge would be more useful for an engineer. He felt that Engineering students should also be given some ideas about public relations.

R.P. ARTHUR felt that teaching humanities in regional languages might be better.

He said that teaching new languages might be taken up, as many students show a liking to study new languages for certain reasons. He felt that this would help the students and the teaching community.

I.O. EBERT said that the home work load got less, as the student came up to the College in U.S.A. and that the students were more concerned about listening to lecture, etc. than on examinations.

R. KRISHNAMURTHY in his summing up said that humanities formed an integral part of Engineering Education. He knew that the student found a course in English difficult to go through. He suggested that a committee should be set up to go through the syllabus and quantum of humanities to be studied. In Indian Institute of Technology the time allotted for humanities for a week of 29 hours was as below:

I Year	-	3 hours English
II Year	-	2 hours for English and 2 hours for German
III Year	-	4 hours History & Economics
IV Year & V Year		5 hours Industrial Management

He felt that if sufficient time was allotted to humanities, the student could be gradually trained in the appreciation of humanities.

He agreed that a knowledge of law would be useful to the Engineers and remarked that a series of lectures of special nature could be arranged to give the engineering students the necessary rudiments of law.

As for the instruction of humanities through regional languages he felt that it might be thought of at a later date, though it was a current problem facing the whole country. He said that it was an excellent suggestion but would need a few more years for implementation. According to him it was upto the University to look into this and effect the change. He said that Krishnamurthy had pointed out that students did not devote much time to humanities and there was a large amount of failures. He felt that much depended upon the teacher to make the lecture interesting to the students.

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## THE ROLE OF HUMANITIES IN ENGINEERING EDUCATION

D.N. NUTTAL

I start with two assumptions - that there is now general acceptance of the function of a technological institution as being the education of engineers, and not merely their training; and that the Humanities have been widely chosen as a suitable group of educational disciplines to serve this purpose by broadening the curriculum of these institutions in order that the students therein may develop an understanding of the world beyond their professional interests.

However, this inclusion of Humanities (or Liberal Studies) in the curriculum must not be held to indicate that all technological studies are of necessity non-humanistic (or illiberal). They may well be, of course, if their sole purpose is to provide a student with a collection of facts and formulae which will enable him to pass an examination. But technological and scientific studies need not be so prescribed. In the hands of enlightened teachers they can, to the degree that they aim at education rather than training, have the same humanistic purpose of developing a sense of values and a critical judgment, of encouraging independent thought and reasoning. As things are in our colleges, however, I think we can agree that science and technology are apt to confine themselves to the accumulation of knowledge; and it is the justification for the

inclusion of our Humanities courses in the curriculum that they can bring, in addition, some accession of wisdom, and some recognisable cultivation of intellect, imagination and sensibility.

It would be as well to define our terms before going any further in order to be certain that we are talking about the same compendium of ideas when we talk about the Humanities. While science and technology are concerned solely with man's environment, the Humanities are studies which centre attention on the life of man. The subject content of these two groups of disciplines is different: so also are their methods. The physical sciences are descriptive, concerned exclusively with what is and what can be proved to be. The Humanities are not only descriptive, they are normative in function; they are concerned not only with what is, but with what ought to be; the reasoning they demand is not only analytical, but critical as well; they involve value judgments and opinions which can be defended, but which are not necessarily capable of objective proof.

This definition of the Humanities, I am well aware, excludes all the social sciences because, although their content is indeed humanistic, their methods are once again descriptive, not normative. The distinction is perhaps familiar enough; but I mention it because there is a

tendency in our institutions to offer courses only in the social sciences, to house them in a department called 'Humanities', and to assume that the humanistic element of an engineer's education is thereby being catered for. I accept the need for a convenient term and I accept that 'Humanities' used in a broad sense can conveniently include the social sciences. But the two terms are not synonymous; and the purpose of providing our young engineers with a broadly based education (one of the assumptions with which I started) will not be adequately served unless disciplines from both these groups are included in the curriculum. There is a disciplinary difference between the Humanities and the social sciences which is in danger of being blurred by our terminological usage; and, without decrying either, we should remain aware of the difference so that both sets of studies are given their due place.

Before discussing the Humanities and the social sciences further, there are perhaps one or two background factors which we should consider in relation to the role of these disciplines in our curriculum, and the selection of studies we may include in order that they may play that role effectively.

The first factor, the one which must be first in emphasis at any gathering, such as this, concerned with education, is of course the student. Unfortunately, he

is often in danger of being overlooked - as you may think if you glance down the list of topics scheduled for discussion during this present summer-school! It is the student who should be the starting point of all our discussions (when we come down to the actual classroom situation, there is nowhere else to start) and our thinking about engineering education will lose direction unless we constantly remember for whom it is meant. In a paper such as this, concerned with the role of Humanities and not with the methodology of its presentation, we can only note that we are dealing with a collection of individual students of varying background and education and at varying stages of maturity (Physical, mental and emotional); and, leaving these individual differences aside, look for common factors. There are, I think, only two broad and meaningful generalisations that we can make about our students - generalisations concerning their age and their ability - but these are important considerations when we are deciding on a curriculum and the role of specific disciplines in it.

The majority of our recruits come to us in their late teens. This means that in the year 2000 A.D., every one of the students in our colleges today will (if he is alive) be still of an age to be employed in industry. Thirty-five years from now - and those of us who can think back thirty-five years to 1930 can bear testimony



to the uncertainties of maturing (and growing old?) in a world very different from the one we grew up in. The next thirty-five years must see an acceleration in the rate of change, and we can guess only rather blindly at what social and industrial life will be like by then. What we do know with fair certainty is that most of the science and technology we are teaching today will be out-of-date whole new disciplines will have emerged and much of our present equipment, textbooks and machinery (even our very departmental titles) will be museum pieces. There is very little purpose, then, in requiring our students to absorb large quantities of factual knowledge when what they will really need is a broad understanding which will enable them to meet change and adapt themselves to technical advances. This prospect calls now for the preparation in our institutions of young men and women aware of the broad range of human endeavour and achievement, alert to their present environment and prepared to contribute to its progress: young people who are used to thinking for themselves. In the cultivation of this habit of mind - the habit of independent, resourceful thought, of critical as well as analytical reasoning - the purposeful study of the Humanities has a decisive role to play.

The other generalisation we can make about our students is about their range of ability - they have all

made the grade and have been selected for engineering studies; and the competition for selection argues that they will all be of average mental competence or better. The significance of this in our curriculum planning is, of course, that the studies we prescribe must be intellectually satisfying; they must make demands on the intelligence of our students; there must be no superficiality or lack of substance in the studies themselves, nor must there be any attempt at selection which produces such attenuation. The role of the Humanities here is indeed a disciplinary one. Every technological institution faces this problem of preparing a worthwhile programme in the Humanities and the social sciences which can be presented to the students in a limited amount of time. (Let us also not forget that whatever time is available, the pressure of other work means that the students are concerned with examination success in the Humanities, and not with the disciplinary value of the studies they pursue). The time limit leaves no room for the details which would be needed by the specialist; and yet, as we have said, the content cannot be so superficial that the student gleans only a few generalities without any insight or understanding. This, in turn, means that we have to apply some process of selection, to choose some meaningful combinations of subject matter, and to offer a course of studies which

will have relevance for the young engineer about to practise his profession in India.

The difficulty of this problem should not be underestimated the problem of framing a course in the Humanities and the social sciences which will have a breadth of scope as well as a depth of interest, and of presenting this course within a time-table allocation which allows of only two or three hours of student contact per week. I should perhaps make it clear that, in talking about a course of studies which will have relevance for the young engineer in India, I do not mean that the disciplines in the Humanities (or in any other department for that matter) should be pruned to meet the specific needs of our students - that Sociology and Economics, for example, in being interpreted as Sociology for Technologists and Economics for Engineers should be reduced (say) to a study of trade unionism in India and an introduction to financing and budgetary control. This is the difference between training and education to which I referred when I began. Knowledge and skill in limited areas such as trade unionism and financial control may well produce a more competent engineer; but they will scarcely help in our efforts to produce an educated one.

There is, in fact, only one decision we can make when we consider the age and calibre of our students and

the responsibility that devolves upon us as their educators. The disciplines chosen for study in a Humanities course must be chosen on their own merits and must be rigorously pursued in order that the students may recognise and appreciate that such studies are as significant as technological ones. It is important, too, that there should be this parity of esteem throughout the institution - the Humanities should not be looked upon as an upgraded extra-curricular activity, nor as a form of easy option or light relief after the efforts of scientific and technological studies. The Humanities course should be as demanding of the students as any other of their studies - if it is not, it can only mean that in some way the students are being given short measure and that a full education is being denied them. My reason for mentioning the relevance of such a course to the needs of our students was not that the content or subject matter should be tailored to their requirements, but that the bearing of these humanistic disciplines on technology ought always to inform the approach to their study and that the presentation of the subject matter should exploit this relevance. This, in our particular case, must mean that sooner or later the courses must concern themselves with contemporary problems in India so that our students are aware of present developments and able to judge future events in a rational way. To take our two previous

examples again, it means that Economics, while preserving its integrity as a discipline, should in our context lean towards a study of economic problems in developing countries and in India in particular; and Sociology for our students must include, without being confined to, a study of the contemporary social structure of India and the situation caused by industrialisation.

Course specifications such as these; and the overriding necessity to present the subject matter in a stimulating and challenging way, make heavy demands on the staff; and the Humanities departments in our institutions need staff of the highest calibre. It is axiomatic that, in order to attract staff of this quality, we must provide for them the incentives of a fully-fledged department in which they will be given the opportunity to handle post-graduate classes and to pursue their own research. The department of Humanities must, as I said a moment ago, have a status equal to any of the larger, if soon to be obsolescent, departments of engineering if it is to play its proper role.

While talking about our Humanities staff and their role in widening the education of our engineering students, it may be worth mentioning in passing that there exists a corresponding need in arts faculties for a broadening of the education provided in them in order that all non-science

students should be introduced to the study of science and technology. From time to time we hear warnings against over-specialisation - but for some reason this generally seems to mean technical or scientific over-specialisation. We live in a world increasingly fashioned for us by technology and science; and no arts or social science graduate can consider himself either an educated man or a fully equipped citizen if he has no appreciation of the application of these studies in our daily lives, if he is unaware of the processes of scientific method, if he is ignorant of the nature of technological advance. This need for giving the non-specialist an insight into the philosophy, history and methodology of science is perhaps more often recognised than adequately met - let us hope that there is somewhere a mirror image of our session here today in which a scientist is explaining to an audience of arts lecturers his idea of the role of scientific and technological studies in humanistic education. This is not entirely by the way, because there is by no means any unanimity about the desirability of an inter-disciplinary education, about the need for breadth in higher studies to avoid over-specialisation, or about the value of cultivating wide interests and abilities rather than narrowing down imagination and attitudes. It was with some chagrin that I learnt that one of the

engineering departments in my own Institute was recommending that its students should in their final year confine their choice of elective subjects to their own specialisation. There is obviously more than one school of thought about the aims of our technological education.

Some factors which might influence us in selecting disciplines appropriate to the role of our Humanities course have been suggested - but no selection can be made which will be appropriate to all institutions; nor is it desirable that it should be so. Provided that the staff are of the calibre required, it is more important that they should bring their own specialisations to life for the students, that they should make the study of them a truly educative experience, rather than that they should try to conform to a uniform pattern of syllabus. Most colleges have evolved for themselves a workable combination of the social sciences from such well-established disciplines as Economics, Psychology, Political Science, Sociology and History (this last being, I feel, a candidate for the Humanities as well). There is, however, less justification for the inclusion of certain 'professional studies' which have latterly encroached upon the already meagre time allocation of our socio-humanistic courses. The provision of a 'Professional background' is no part of the role of the Humanities in engineering education;

and although programmes such as Management Studies or Industrial Administration may make our students more competent employees, they will not serve to broaden their education to any marked degree. The maturity required for a proper appreciation of such studies, and the background of experience which alone can make them meaningful, suggest that they would be better offered as Post-Graduate or Diploma specialisations rather than as undergraduate courses.

A final word now about the Humanities courses themselves - the normative disciplines discussed earlier - of which language and literature, philosophy, the fine arts and, perhaps, history are the main examples. Applying only the criteria of relevance and utility, it is more difficult to justify these as suitable disciplines for engineers than the social sciences, whose subject matter is bound to impinge at some points on industry and industrial society. Yet they must remain as the core of our Humanities course if the role of that course as we have defined it is to be fulfilled - if we are to succeed in providing our students with some independence of judgment, with the faculty of critical appreciation, with the ability to evolve for themselves a system of values in a changing world. Once again no preselection of disciplines is indicated - but we cannot leave this topic without some



reference to the special position of English in engineering education in India.

It is necessary to be quite clear about the two separate functions of what are generally called English studies. For most of our student engineers the study of English is purely and simply as a 'tool' subject to enable them to follow their technological studies without constant linguistic difficulties. This kind of language course bears much the same relationship to engineering as does mathematics - it is a supporting or service discipline - and it plays no part in the role for which we have cast Humanities. Only to the extent that an English course involves a study of English literature can it be appropriately housed in a department of Humanities - English literature, that is, which has not by definition to be a hundred years old but which includes the work of contemporary writers. Indeed it would be possible to base an entire liberal education on a systematic study of 'great books' of literature in its widest sense including the classics of philosophy, history, politics, theology and science - a study which would carry us from the oldest times down to the present day (I am not here attempting to compare or contrast the value of an English language course with one in English literature - the former is still a minimum essential for engineering education in

India - and proficiency in the language is necessary before a study of literature can play its role in the Humanities course).

The role of the Humanities in engineering education as defined in this paper is capable of fulfilment only to the extent that one main danger is avoided - the danger already alluded to of superficiality of content and lack of rigour in presentation - the danger of supposing that these studies can serve their purpose by indoctrination instead of intellectual discipline. Having included these disciplines in our curriculum in order to open wider horizons to our students, let us remember that the Humanities can achieve their object only by virtue of their subject matter and of the ideas they present; and that these ideas can mould the minds of our students only to the extent that they are critically studied, evaluated and absorbed.

## DISCUSSION:

R. SAMUEL said that the speakers have pointed out that teaching humanities to Engineers would broaden their horizon. He felt that there was a general lowering of standards at all levels in the Western World. He suggested that humanities should be studied in a coordinated way in keeping with the times.

T.R. NATESAN said that the teacher of humanities should be humanistic in his approach to the subject. He felt that they should be more humanitarian. In teaching humanities, there should be absolute freedom. He also said the teachers must be in a position to inspire the students from a humanitarian angle. He suggested that regimentation in education was the source of all evil and that affection must be bestowed to receive affection.

NARAYANA RAO suggested that humanities could be called moral science or moral Engineering. He felt that it would be better if there was no examination in humanities. He also made a suggestion that Sanskrit might also be taught in colleges.

S.T. NAGARAJA said that the developments of Technology and its fruits were for the human beings. He felt that it was unnecessary to worry about humanities. According to him, since an Engineer had to deal with men, money and materials, he was no engineer, if he would not

utilise these properly. He said that in the education of an engineer the humanistic aspect was already incorporated and hence there was no need for a separate approach to humanities.

S. RAMA GOWDA said that the technologists and engineers in the quest of greater comforts forgot one basic aspect - that they were men. He suggested that our syllabus, now being science and technology oriented, must be changed.

D. KAMALAKANNAN said that the gap between the Humanities culture and Science - Technology culture was widening.

A recourse to greater quantum of humanities in Engineering institutions would curtail over-specialisation. He also said that since it was unpalatable to Engineering students, it would be better not to introduce any subject of humanities.

V.C. KULANDAISWAMY raised the question as to the quantum of humanities in Engineering Education. He said that after having decided this, we should decide the levels at which this quantum is to be offered. He said that the American Society for Engineering Education had gone into this question and had decided that humanities must be taught over the entire period of Engineering education, According to him, they apportioned 20% of the total time spent to humanities, 25% of basic sciences, 25% to Engineering Sciences and 25% to Analysis and Design.

D.N. NUTTAL in his summing up remarked that humanities discipline must be spread over the whole period of Engineering education. He suggested that the time aspect and content of syllabus was to be decided by educators or committees from time to time depending upon the prevailing conditions. He warned that India was also in danger of becoming over - materialistic and that this must be guarded against.

Humanities could not be called moral science as the approach and objective of the former is different. Abolition of examination would not be possible as it will remove the importance of the subject.

He was gratified to note that there was a greater interest to the incorporating of humanities in Engineering Education.

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## CURRICULUM OBJECTIVES IN RELATION TO LABORATORIES

V. KALYANARAMAN

The subject of my talk is curriculum objectives in relation to laboratories. I propose to say a few words about curriculum and then the function of laboratories in so far as they contribute to the understanding of the various subjects in the curriculum. I do not propose to say anything about the actual conduct of laboratory classes.

Technical education is one of the most sought out fields of activity of the present generation. A number of courses are offered in different branches of Engineering and Technology in colleges and polytechnics to degree and diploma standards. The content of the Engineering curriculum of these courses has to be worked out after arriving at a clear understanding of the objectives of such a technical education. These objectives are based on the technical and social responsibilities that must be assumed by graduates expecting to enter the engineering profession in this country. The engineering activities for which we will be training the engineering graduates will be varied and many. Engineers may be concerned with basic scientific research at one extreme and practical application, use and maintenance of systems and devices at the other. Between these extremes engineers are also concerned with the functions of development, test, evaluation, manufacture and marketing. It is clear that

an education which is best for one type of activity is not necessarily suited for another. When we think of engineering curriculum, the remarks of the Secretary of ASCE in Civil Engineering October 1964 will not be out of place here.

"There is growing concern within the older branches of engineering with the change in emphasis in engineering education that affects the balance between science and technology. For a decade or more this emphasis has been moving steadily in the direction of engineering sciences, largely as a result of an attempt to standardise the education of all engineers. The desire of many schools today to cater to the sophistication of electronics, nuclear and space science is taking a reactionary turn in the fields of Civil, Mechanical and Mining Engineering and possibly in other branches".

The electrical engineer of 1930 was primarily engaged in the production and distribution of electric power and radio communication was in its infancy. To-day the "product mix" of the Electrical Engineering is dominated by electronics as applied to such innovations as television, computer design and automation. In this extreme transition it has become necessary to convert the electrical engineer to an electrical physicist.

In Civil Engineering, on the other hand, the change in "product mix" has not been so pronounced through the years. True, the bridges, dams, water and sewage works, buildings and special structures today are frequently larger and more complex. It is true also that there have been notable advances in computer application techniques and in the mechanics of soils, fluids and stress analysis. But the changing demands of project development and the advance in technique have not required the revolution in civil engineering education that has taken place at some institutions to accommodate the changes in other engineering disciplines.

In 1930 the four year Civil Engineering graduate was admittedly deficient in mathematics, engineering mechanics, economics etc. He was well prepared however in design technology. Today the recipient of a bachelor degree in civil engineering is likely to lack basic training in engineering design as well as economics, communication. In view of this he is expected to be better equipped in mathematics and engineering mechanics. Thus the engineering curriculum goes on changing. Perhaps in a developing country an education with emphasis on design, application and current practice would be useful to obtain the highest productivity, economy and efficiency.



The important components of an engineering curriculum are the basic sciences, the engineering sciences, the engineering analysis and design, the engineering laboratories, the technical courses outside the major field, humanities and social studies.

The basic sciences which are considered as the foundation of engineering are Mathematics, Physics, and Chemistry.

Engineering Sciences comprise the following fields:  
(1) mechanics and properties and strength of materials  
(2) Fluid mechanics, (3) Thermodynamics, (4) Electrical theory (fields, circuits, and electronics). Analysis, design and development of engineering systems are the most distinctive features of engineering curricula. The Committee of Evaluation of Engineering education of the American Society for Engineering Education states "The capacity of design includes more than mere technical competence. It involves a willingness to attack a situation never seen before and for which data are often incomplete. It also includes an acceptance of full responsibility for solving the problem on professional basis". This portion of the engineering curricula demands our attention.

Next comes engineering laboratories. Laboratory exercises are expected to accomplish the following:

- 1) To substantiate theory which has been presented in text and lectures.
- 2) To teach the experimental method, which is to observe phenomena and seek explanations.
- 3) To concern with the art of measurement including analysis of accuracy, precision and errors.
- 4) To develop skill in the written presentation of engineering information.
- 5) To develop in the students a degree of self reliance and ingenuity and a chance to demonstrate resourcefulness.
- 6) To promote the teacher-student relationship.
- 7) To develop in the student a spirit of accomplishment through team effort.

The A.S.E.E. report states "The laboratory is the means of teaching experimental method. It should give the student the opportunity to observe phenomena and seek explanations, to test theories and note contradictions, to device experiments which will yield essential data and to interpret results. Therefore laboratories should be used only where these aims are being sought. The value of a set number of stereotyped experiments is questionable.

The value of a set number of smaller number of appropriate experimental problems by the students themselves under effective guidance will have much greater educational value.

All of us know that laboratories are necessary and that lecture and laboratory are complimentary to each other. All of us know that adequate laboratory experience is necessary for developing a well-prepared student engineer. Subjects like Surveying require considerable amount of practical work which one may call as laboratory work. When curriculum is drawn up for such subjects this aspect should be remembered. However motivation is as variable as the wind. Many individuals voluntarily undertake the effort to educate themselves. Others require more or less encouragement. Laboratory work generally generates action in the individual to the end that he may utilise the available opportunities in the laboratory for improving his fund of knowledge.

There are two basic patterns to the conduct of laboratory programmes. These two patterns may be stated as follows:

- 1) the development of a sequence of laboratory exercises which are presented with step by step instructions as a guide for the student.

- 2) Another pattern is the type of programme where the end results only are specified and a laboratory group is permitted to plan the test, select the equipment and carry out its own project.

In the undergraduate course in the early stages, perhaps the first pattern is to be preferred. For good results it is necessary that the laboratory work should follow a parallel course with class room lectures. For example, when flow through pipes is being dealt with in lectures the laboratory work should deal with the determination of friction factor. This may be difficult when a large number of students have to be handled. When the equipment is limited, it may become necessary to do experiments even before the topic is covered in theory classes. This procedure only enables the student to do the experiments mechanically without understanding the full significance. Therefore, careful planning of the proper sequence of the experiments is necessary. It will be an advantage if the teacher who lectures also handles the laboratory class. This ensures co-ordination between the two phases of the same subject, lecture and laboratory work and there is more contact between the student and teacher. This gives an opportunity to the

student to approach the teacher to have his doubts cleared. The familiarity brought about by greater contacts will often generate greater enthusiasm on the part of the student for his study.

Further laboratory work develops in the student a spirit of team work. It is usual in a laboratory that the work of various parties of students are pooled together before the final results are tabulated. Thus, an engineering laboratory provides an arena where co-ordination and team work in group effort may be developed. This experience may be useful later, when the individual goes to work in a project.

Some of the laboratory programmes may become less and less effective with the passage of years. Some times experiments are simply devised to keep the students busy and to give experiments to a large group of students. An example is tests on a number of centrifugal pumps whose principle of operation is the same and the only virtue they possess is they are made by different manufacturers. Students' time should not be consumed in repetitive and routine jobs. Whenever students carry out experiments they should take readings carefully and calculations should be completed there itself. Results obtained should also be interpreted carefully wherever possible

graphical representation of the results will be very helpful. The students should cultivate the habit of analysing the results as objectively as possible. In this context, the remarks of John R. Freeman may not be out of place:

" I have seen so much of the danger arising from presenting results or rules involving variable co-efficient in the form of algebraic formulas which the hurried or careless worker may use far beyond the limit of experimental determination that I present the results mainly in the form of plotted curves which cannot be thus misused and which clearly show the margin of uncertainty and the limitations of the data". To develop an effective laboratory programme, it is very necessary that the student comes to the laboratory well prepared to carry out the experiments and goes about his work methodically with an enquiring mind.

In order that the students may get the maximum benefit out of the laboratories the laboratory teacher has to satisfy the following requisites. The teacher should feel he is teaching the students and should take a personal interest. He should provide inspiration, incentive, encouragement and help to individual student. He must have the equipment fully prepared and have the programme fully planned. He must demand honesty, precision and care from students, emphasise keen observation

and promote inquisitive attitude. He must be enthusiastic and try to be one of the students himself. He should not pretend to know everything.

While in the early stages, laboratory work must be so designed as to supplement what is done in the lecture class, in the senior classes, laboratory must be used as a place to develop student initiative and responsibility. It must be used as a place of learning rather than to do specific experiments to verify theoretical conclusions. With proper guidance the student should be allowed to use his initiative and ingenuity to experiment and report worthwhile information obtained. The emphasis must be on approach to new problems. The student must be encouraged to gain confidence to attack new problems. In some Universities, project work is given in the final year classes. The project work serves a similar purpose as the laboratory work. This gives an opportunity to the student to employ what he has learned during his entire engineering studies.

As regards equipment in a laboratory, it is not necessary that a laboratory should have costly and sophisticated equipment. The general tendency is to use simple and inexpensive equipment. There should be good workshops available nearby where it may be possible to fabricate some of the equipments required. The student should be encouraged to devise suitable equipments. While in the

initial stages, this may be difficult, in the long run this will pay dividends. If research projects are to be taken up in laboratories, the laboratory staff should be able to give necessary help in the proper instrumentation. In many cases, suitable instruments have been devised then and there for measurement purposes. It is not always possible to buy instruments in the market and use them straightway.

Before I conclude, please permit me to quote Louis Pasteur:

"Take interest, I implore you, in those sacred dwellings which one designates by the expressive term 'laboratories'. Demand that they be multiplied, that they be adorned. These are the temples of the future - temples of well-being and of happiness. There it is that humanity grows greater, stronger, better".

I thank you for your patient hearing.



## DISCUSSION:

R. SAMUEL said that the objectives of laboratories were:

- 1) To make the student understand the functions of the equipment and gain confidence, and
- 2) To improve the design of certain equipments,
- 3) To acquire analytical skill of the experimental results, and
- 4) To gain a humanistic approach to various problems.

N.M. JANARDHAN said that in his talk, the speaker has stated that the desire of many schools to-day to cater to the sophistication of Electronics, Nucleonics and space science is taking a reactionary turn in the fields of Civil, Mechanical and Mining Engineering and possibly in other branches. He felt that it should be called revolutionary turn and not reactionary turn. He stated that electronic circuit theory was not much different from Electrical Theory. He felt that they should not be differentiated.

Md. SULAIMAN said that the students must be given a complete set of experiments on one particular equipment itself instead of repeating the same experiment on a variety of similar equipment.

M.N. NARAYANA RAO said that the laboratories should serve as a place for exchange of knowledge of information.

H.S. SHIVASWAMY remarked that the laboratory should not be relegated to a place of only examination importance. The Government should take the responsibility of manufacturing all the equipment required by the laboratories. According to him laboratory must be a place of practical training.

T.R. NATESAN said that abolition of examinations in Laboratory work would be detrimental to the education of the student as he would not show any interest in practical work.

He suggested that the staff teaching the subject should accompany the student to the laboratories also, as theory and practice should go hand in hand. He said that large number of experiments in laboratories would help correlate theory and practice.

K. VENKATASUBRAMANIAM said that laboratories should be equipped with the same equipment, that the student would encounter in practice.

T.S. SWAMY remarked that project work would serve as something more than the laboratories since in the former originality is given a place. He felt that design of instruments would probably be more useful for successful research.

E.C. CHANDRASEKARAN felt that students must be made to come into contact with the equipment freely. According to him, unless the students have a clear idea of the

laboratory equipment, they would not be able to devise new instruments must be encouraged.

G. EKAMBARAM said that a well prepared laboratory manual should be placed before the student.

V.C. KULANDAI SWAMY said that all problems of Engineering are problems of prediction. According to him, the object of Laboratory work was to introduce to the Engineer the method of acquiring knowledge by experimentation.

He remarked that to that extent, the student should be capable of collecting data, analyse them critically, and draw conclusions and present a report. In his opinion laboratory was a place where the student should learn to appreciate accuracy in measurement.

S. NARAYANA BHAT suggested that unnecessary laboratory work must be avoided by a coordination of Professors of all branches.

R.P. ARTHUR said that the laboratories could be divided into two classes:

1. Laboratories which provided only certain data or information.
2. Laboratories which needed a knowledge of equipment in a complete aspect for their functioning, a diagnosis of defects in them and the methods for restoration. Hence, the student who went to the second category of laboratories should be able to look at the equipment from all

those three aspects: construction, defects and tests for proper functioning. He suggested that students should be provided with standard results so that he can compare his own and offer remarks on any vagaries.

Another of his suggestion was that a questionnaire and details regarding the data to be taken should be furnished to the student and a tabular statement might be furnished for each experiment done. In his own opinion the object of laboratory training was to devise methods of experimentation to arrive at the defects of equipment.

He also suggested that concentrated laboratory work over two or threeweeks during an academic year might be thought of. In his summing up, V. Kalyanaraman said that changes in curriculum were only reactionary and not revolutionary. He also said that it was the view of many eminent Engineers that electronics must be a separate discipline, distinct from Electrical Engineering. He reiterated that the laboratory could not be a place for practical training. According to him it should help the student for an analytical design approach to all problems. He felt that the suggestion of concentrated Laboratory work should be examined carefully.

## PREPARATION OF LABORATORY EXPERIMENT

T.S. VENKATARAMANAN

### NEED FOR AND OBJECTIVES OF LABORATORY TRAINING:

"Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice, is applied with judgement, to develop ways to utilise economically, the materials and forces of nature for the progressive use of man kind". To the extent the engineer over designs his structure or mechanism, he is magnifying his cost unjustifiably, which is not good engineering. To the extent he fails to foresee and allow adequately for adverse factors, he jeopardises both the usefulness and safety of his structure and likewise his professional standing. By superimposing certain mathematical techniques, his own judgement and constructive imagination on accepted rules of good practice - the accumulated experience of his professional predecessors - the engineer achieves a balance between too good and too poor.

Forty or fifty years ago progress was perhaps made by trial and error. To-day many problems are studied in detail before designs of new structures or machines are accepted. Any favourable characteristics which may exist can therefore be exploited to their utmost, and faults eliminated. Many investigations are carried out

experimentally and require a good laboratory technique to reach satisfactory conclusions.

The engineer has therefore to be properly educated to meet all exacting conditions he may be exposed to, in his career. He should not only have adequate mathematical and scientific knowledge, but should also be educated to use that knowledge to suit conditions on hand. It is in developing this judgement, that practical experience counts. A beginning in the acquisition of such an experience can be made in the laboratories and workshops of the College, though they have, of course, their limitations. There is a philosophy to-day, that there are two objectives in engineering education, - namely, training in the engineering sciences and training for professional engineering, and that each differs considerably from the other, both in the objectives, and disciplines required for success. Whichever of the two objectives one has in view, the capacity of the engineering student should be so developed, that, when faced with a new and unfamiliar situation he must be able to handle it with competence.

Mathematical research or analysis is invariably ahead of experimental practice. But, in many cases, the last word can be said only after experimental verification by a laboratory or full scale test. One has a better grip or confidence in the final result, in

complicated and unfamiliar circumstances, after an experimental verification, before important decisions are taken on an engineering project of great cost and consequence. For one who has not tasted sugar, it is better to actually put a few grains of it in his mouth, than read all about it. One may have read that mild steel obeys Hooke's law. But it will be real education to see a 2 inch diameter mild steel rod subjected to tensile force extend in length and get back to the original length like a piece of rubber, when the force is released. If the pulling force is increased to break it into two pieces, it will be greater education to note that ultimately its length near the breaking zone has increased permanently by as much as 25% of its original length. Many such simple examples can be cited.

I have taken some pains to show that laboratory training is necessary to an engineering student, because, I find that there is a tendency on the part of some, to reject certain disciplines like surveying, drawing, and even laboratory training as superfluous, or time wasting. There is a suggestion to substitute the laboratory classes by visual education classes, and screening the details of experiments including report writing. It is claimed that time and cost are saved thereby. This will not suit conditions in our country, where few of the boys choosing an

engineering career have had opportunities to develop the proper bias, and perhaps have not handled many tools, not to speak of machines or delicate instruments, before joining the engineering college. If this method of imparting laboratory instruction is adopted, their engineering knowledge will be divorced from first hand knowledge and be completely bookish.

The objectives of laboratory training may be summed up as follows:

- i) to substantiate the theory which has been presented in texts and lectures;
- ii) means of teaching experimental method;
- iii) learn to set up an experiment for ordinary or research purposes;
- iv) recognise variables;
- v) develop the technique of measurement including analysis of accuracy - precision - and errors - appreciation of degrees of accuracy;
- vi) application of statistical methods in the analysis of varying results;
- vii) a medium through which the student develops a degree of self- reliance, ingenuity and judgment;
- viii) cultivate team spirit in the solution of problems;
- ix) report writing.



Whether it be in the undergraduate or post-graduate classes, these are the main objectives. The difference is only in the nature of the complexity of the problem, and hence, the number and duration of tests, and report writing.

#### PREPARATIONS REQUIRED:

The question then arises as to how these objectives are to be achieved, and what are the preparations required therefor. The three factors which are involved and which will influence the quality of the achievement will be

- i) the student
- ii) the teacher
- iii) the equipment

and each one of these should be properly prepared to ensure satisfactory realisation of the objectives.

#### THE STUDENT:

Student participation is as important in laboratory classes as in any other class. Of course, conditions should be created in which the student will find it interesting and fruitful to participate. In this direction, a good laboratory manual will be of great help. The manual should be written for the laboratory conditions, by the teachers who have themselves conducted the various experiments. The manual should be helpful in training the student to observe, think, react, and encourage him to write clear and meaningful reports. The student should be

told in advance as to what experiments he has to do in the course of the term, or year, so that he may come prepared to the class. Tabular forms for recording data may be furnished to the student, but he should also be trained to do this on his own, particularly in the higher classes.

The grumbling sometimes heard about "the time honoured cycle of experiments" either from the student, or the teacher, is a negative approach and is unhelpful. Distinction must be made between 'experiment' and 'test', although they are generally used loosely to mean the same thing. 'Experiment' involves the idea that the outcome may be uncertain, and hitherto unknown results may be forthcoming. 'Testing' involves the idea of a more or less established procedure and that the limits of the results are generally defined. Experiments planned on a large scale (as in the post-graduate courses, and research) ordinarily involves many routine tests. Although the purpose, point of view, and method of attack may differ widely between research work and routine laboratory work, (as in under-graduate laboratories) many of the detailed procedures may be the same in both cases. The student who takes up research should be familiar with all the "routine" tests and he must have been trained in them. It must be accepted, that too much novelty and excitement cannot be expected in them, as for instance, in 'shooting

rockets into space'. The engineering student in these initial stages of laboratory training, is like a child, who must learn to roll on his side, crawl, sit up, stand and walk before he can run.

In the post-graduate and research laboratories, as has been explained already, there is room for wider variety of tests, instrumentation, greater opportunity for the student to use his ingenuity in designing the experiment, take readings and drawing his own conclusions. There is scope for some novelty and excitement, but it must be understood, even then, that there will have to be a lot of perspiration as well. A research worker, who has no patience, and love for his work will achieve nothing worthwhile. Without proper interest and motivation in the student, nothing useful will result. What is being done in the undergraduate classes, is the necessary training ground to what he may have to do later.

#### THE TEACHER:

The sincerity and patience of the teacher, and his ability to teach and guide the student in his work, are particularly important in a laboratory. He should be personal, having to deal with smaller numbers of students at closer quarters. He must himself know all about the tests. The tests should be designed to suit the limitations of time, skill, equipment, cost and its effectiveness.

in helping the student to learn the fundamentals of the subject. The questions to be considered in the design of tests are:

- i) What is the nature of the answer sought?
- ii) What test can be made to provide the answer?
- iii) How will the test results be related to performance?
- iv) What are the limitations of the type of test selected? Does it measure adequately a property that is sufficiently basic and representative, that the results can be used directly in design? Or the test even though arbitrary, serves to identify materials and are only of comparative value?
- v) How should the precision of the work be adjusted in accordance with the limitations?
- vi) What type of specimen is best suited for the test?
- vii) How many tests (or samples) are necessary to obtain representative results?

These points should be borne in mind and tests (or experiments) should be selected, and so arranged that it is possible for the student to complete the test within the time prescribed, get his results checked by the teacher, repeat if necessary, and write up the report also. The class should be split up into squads consisting of ordinarily not more than 2 students in each, for

proper effect. Some tests, which involve a number of repetitions, may be broken up and given to the different squads. To cite a simple example, if the effect of water-cement ratio on the strength of cement concrete is to be studied, the different squads in a class may be assigned a particular water cement ratio, for investigation, but, the results of all the squads may be pooled at the time of writing the report. The report so written, will be complete, useful, informative, and help to initiate team spirit in laboratory work. A sample report, showing the matter to be included, and form to be adopted, including graphs and conclusions, may be shown to the students as a model, in the early stages of laboratory training. Strict discipline should be maintained in the submission of laboratory reports in time. Students who were absent for any test, should be given opportunity to do them and catch up with the rest of class.

#### EQUIPMENT:

The equipment in a laboratory requires as much preparation as the student and the teacher. The adage "A bad workman complains with his tools" may be true. But, it cannot be gainsaid that good tools are concomitant to good work. The equipment for a laboratory should be selected carefully. For the undergraduate course, it should be simple, purposeful and adequate

in number. There is no need for the so-called 'Unique' ones, which are overbig and duplicates of the latest in the Industry. They are not useful in teaching fundamentals. All equipment should be kept in good calibration. The teacher himself should be familiar with all of them. The principle of their working (particularly the complicated ones) should be explained by line diagrams and charts, and displayed on the wall close by, for easy reference. There should be adequate space all round each equipment (4' would be ideal) for students to move around it with safety.

Equipment may be generally classified as

- i) General apparatus or machines
- ii) Devices for measurements
- iii) Those used for calibration, and adequate numbers of each of these and of proper range and quality, should be acquired for the laboratory, depending upon the courses offered.

In the post-graduate laboratory, more sophisticated equipment may be called for. Even here, a resourceful, and helpful teacher can rig up any device for a test, given certain basic equipment of the proper type. If the student has had a good grounding in conducting the various tests in his undergraduate laboratory, he can use his ingenuity in every aspect of his laboratory work

to tackle any engineering problem in his career, with minimum guidance. Taking the simple "Tension test on Metals" I have indicated in Appendix I, the various points, the teacher should consider in the preparation of the experiment, so as to imprint a complete picture of the experiment in the mind of the student.

#### CONCLUSION:

Testing is a tool, even as mathematics and science are, to an engineer. Testing or experiments should not be used as a substitute for thought, although it may be found that an appropriate experiment may aid in an analysis. Before a test is undertaken the purpose of the test should be understood and the general character of the results kept in mind, planned intelligently, anticipating all possible difficulties. The student must be trained to visualise what goes on behind the various operations of a test. For instance, in a structural test, he should be able to follow the paths of stress, deformation, reactions etc. He should be taught to be aware of the opportunities for error and be quick to see them.

The preparations for a laboratory experiment will therefore be found to be simple and at the same time complex. Preparation includes:

- i) design of laboratory buildings
- ii) selection and installation of equipment

- iii) keeping the equipment in good calibration
- iv) preparation of a good, brief, and useful manual
- v) adequate study by the students and staff before going to the laboratory
- vi) organising the laboratory experiment to keep up the interest of the student and rouse his curiosity
- vii) readiness to make changes in the laboratory procedure when required
- viii) deputing adequate number of teachers in the laboratory (one teacher for 10 to 12 students is desirable)
- ix) Presence of senior members of staff to induce and advise on the efficient organisation and conduct of the laboratory classes.

I have not dealt with the details of the actual conduct of experiments - report writing, grading etc., and I presume that they would be done under some other topic.

May I, therefore, in conclusion invite your kind attention to the important requirements of an 'Engineer' enunciated in the definition of 'an engineer' at the beginning of this talk, namely, knowledge of mathematics and engineering sciences, experience and judgment. Mathematics and engineering sciences can be learnt in lecture classes while, experience and judgment are to be acquired by oneself outside the lecture classes.



An engineering student, who is really interested and motivated can get his first lessons in the acquisition of these qualities also (experience and judgment) in the laboratories, so that he will be better oriented to meet any situation in his career with skill, resourcefulness, dignity and leadership in the task of devising efficient ways of utilising the materials and forces of nature for the progressive use of mankind.

I thank the organisers of the Summer School for giving me the privilege and opportunity to share these few thoughts with members of the distinguished audience to-day.

## TENSION TEST ON METAL

The following points should be borne in mind in the preparation of the Experiment on "Tension Test on Metal".

## AIM :

To study the characteristics of a metal, subjected to increasing tensile force, in the elastic and plastic ranges and to determine the Young's Modulus. Knowledge of these properties is necessary in selecting safe dimensions of a structure or parts of a machine.

## SELECTION OF MATERIAL:

It is necessary that students should study first hand the characteristics of the important and most used metals in engineering. The following metals may be chosen as representative: (i) Mild Steel, (ii) High tension steel (iii) Cast iron, (iv) Copper (v) Brass (vi) Aluminium.

## REQUIREMENTS OF THE TEST SPECIMEN:

- i) Shape: Ordinarily circular cross section though square or rectangular cross section may also be used, depending upon requirements. For important tests, the central part in the length of the specimen is reduced in cross section to ensure failure taking place in the central part, to facilitate study during test and for correct results.
- ii) Length of specimen required: The total length of the specimen is made up of (i) The gauge length, (which is a factor of the diameter of the bar) varying from 2" to 8" ordinarily, depending upon the extensometer to be used.

(ii) the grip length required on either side which again depends on the type of grip adopted or available (iii) the shoulders (distance between end of grips and gauge points) whose function to prevent the effects of the grips and change in diameter affecting the stress within the gauge length (minimum twice the diameter of the rod).

(iii) The number of specimen to be chosen to confirm reproducibility of the results (ordinarily 6 specimens are indicated).

#### THE CHOICE OF LOADING MACHINE:

The loading machine should suit the following conditions:

- i) Its range should be adequate to permit sufficient load being applied on the specimen to break it.
- ii) It must have suitable grips to accommodate the specimen ends. The different types of grip ends namely (a) the shouldered end (b) threaded end (c) the commercial rod with no special ends, have their purpose, and the choice of the particular type should be explained.
- iii) For certain kinds of test the rate of loading is specified (For tension test, a movement of the cross head at 0.05" per minute is ordinarily prescribed) The need for such regulation of the speed of loading should be explained and such regulation should be possible on the machine.

### CHOICE OF STRAIN GAUGE FOR THE EXPERIMENT:

The various types of extensometers such as the mechanical type (of various kinds) optical type, and electrical types are available. The student should be instructed about all of them and the circumstances under which each of them are used - from the point of view of

- i) accuracy required
- ii) ease of operation
- iii) cost, consistent with the requirements of the project
- iv) ability of the student to handle them.

Having instructed the student on the choice of the specimen and equipment, the procedure to be adopted can then be explained.

### OBSERVATIONS:

What are the points to be observed?

- i) the dimensions of the specimen
- ii) marking the gauge points and measuring the distance between the points
- iii) Application of load and reading the strain-guage at specific loads (including removal of extensometer at the proper stage to avoid damage to it) i.e. near elastic limit.
- iv) Further measurements of load and elongation till the failure of the specimen.

## DATA TREATMENT:

- i) Calculate stress strain for each load upto failure.
- ii) Plot stress strain curve
  - (a) to a bigger scale upto elastic limit.
  - (b) to a smaller scale the complete curve, marking the proportional limit, upper yield point, lower yield point, ultimate stress and breaking stress.
- iii) plot similar curves for the various metals on the same graph for easy comparative study of the characteristics of different metals.
- iv) Calculate the Young's Modulus, percentage of elongation, percentage of reduction of area.
- v) Let the student study the changes that have taken place between the guage length including the fractured surface and write a comparative note.

Questions should be framed and answers obtained orally and by writing on some points indicated below:

- i) the significance of certain aspects of the test like the choice of the length of guage, strain guage used, rate of loading etc.
- ii) The practical utility of the results obtained in the test.

- iii) Chances for errors to occur and how to avoid them.
- iv) Purpose of the determination of yield point.
- v) How to determine the yield point without calculation.
- vi) How to determine a reasonable yield point of metal which does not show a definite yield point in the stress strain curve.
- vii) Explain the terms (a) ductile metal (b) brittle material and explain their characteristics with reference to their stress strain curve and pattern of fracture in a tension test.
- viii) From the stress strain curve indicate the elastic region and plastic region and explain what happens to the specimen in those ranges.

#### DISCUSSION:

S. NARASIMHAN said that it was not always essential that experiments should be conducted only on larger machines. Even with small machines, good results could be achieved. He suggested that examinations in laboratory work could be eliminated and attendance made compulsory and that a certificate that a student has attended all laboratory work might be given to qualify him for writing the theory examinations.

S. SANKARALINGAM said that students should not get the idea that breakages would mean heavy fines. The student should be free to handle all equipment with care. When the students were in the Laboratory, he wanted the staff to take active part in their work or tests. He suggested that rigidity in the cycle of experiments should be avoided. He was against abolition of examination in practicals.

P. PURUSHOTHAMAN said that design of the laboratory itself should be done properly and that laboratories must be in small units. According to him Laboratories need not be manned by degree holders and diploma holders would be enough. He suggested that the position of laboratories, technicians must be improved and that duplication of equipment must be avoided.

G.T. SRIRAMULU said that experiments must be set up to motivate the student for laboratory practice. Duplication of equipment could not be avoided when institutions were large. He suggested that students should be trained both in sophisticated and common type of instruments. In his opinion examinations in the practical classes could not be abolished. He was against diploma holders being put in charge of laboratories as they could not be expected to teach the laboratory practice.

A. SARGUNAM said that the aim of the laboratory experiments was not only to just conduct certain tests but develop the initiative to build up experimental units. He was sorry that students did not interpret the results of their tests and that they were mainly examination minded. He further suggested that laboratories might be provided with a separate room where models of the equipment, charts, manufacturers' leaflets etc. might be exhibited. He felt that laboratory manuals were very necessary.

VISWANATHAN said that laboratories could be used to initiate creative thinking. He felt that design of structures etc. by model studies in laboratories would be a good addition to our undergraduate Laboratory work. He suggested that experiments should be devised to gain ideas of quality control.

PANIKKAR strongly felt that equipment available and manufactured in India, must be utilised to the maximum extent, saving valuable foreign exchange. He suggested that there should be full cooperation between departments.

In his summing up T.S. VEMBATARAMAN said that it was not the magnitude or size of the equipment in the laboratories that matter, but if they could demonstrate the fundamentals even with small and modest equipment, it would be quite sufficient.



The examinations in Laboratory practice have their own value and if they were conducted properly, they would be useful. According to him, examinations were necessary evils.

He was of the opinion that mischief on the part of students should be watched and breakages purely out of playfulness or ignorance must be avoided.

He said that separate sections for each laboratory would mean increased number of staff and that it would not be suitable for Indian conditions. He felt that only a B.E. Degree holder would be good for laboratory charge and that the laboratory provided a place for administrative experience and opportunity to clear all his doubts for his subjects. Duplication of machines would be better to keep pace with advancement, and to provide experiments to the large number of students. A central organization in an institution should be entrusted with the task of maintenance. He said that destructive and non-destructive tests were necessary in the curriculum and must be learnt by the students. He agreed that interest in the boy must be motivated. He felt that research in undergraduate laboratories at present is impossible due to lack of time and lack of staff.

He did not accept the suggestion that experiments should be devised to gain ideas of quality control. He agreed that it was good to use indigenous equipment. But he warned that so long as they were not upto the standard, a standard foreign equipment should also be available.

## PREPARATION OF LABORATORY EXPERIMENTS

K. ACHUTHAN NAIR

All laboratory work connected with the teaching of Engineering have certain basic objectives. Before dealing with the preparation of experiments we may briefly state some of these objectives as follows:

- 1) To develop the experimental method of study
- 2) To augment and complete theoretical aspects of Engineering Education
- 3) To introduce the student to standard methods of measurement
- 4) To cultivate a critical attitude towards all observations
- 5) To foster creative ability
- 6) To develop team spirit.

The experiments have to be prepared with one or more of the above objectives in view.

The first essential in preparing the experiments is to have a scheme of experimental work. No topic can be taught purely by laboratory experiments. There has to be some theoretical instruction. Generally speaking, students cannot carry through experiments adequately without theoretical background but one cannot be hard

and fast about this. Some theory teaching is bound to benefit from prior knowledge of the practical situations from which the theory arises. We have also to take note of the fact that the number of students handled by the laboratory may be large as compared with available equipment and teaching staff. The best practical solution will be to form the experiments into groups. Since our institutions generally have three terms in a year we may have at least one group of experiments per term. The first group may comprise simple experiments and the succeeding groups progressively more difficult ones. To the extent possible, each group of experiments may be broadly related to the topics being dealt with in the lecture classes. The experiments in each group may form a laboratory cycle, each student completing the experiments in turn. After the cycle is completed there may be one or more classes for those who happened to miss an experiment or wish to repeat some experiment. This scheme of work can be exhibited in the laboratory so that each student knows what experiment he has to do next and can be adequately prepared for it.

A point to be considered is the number of students that should form a batch doing one experiment. Crowding of too many students on one experiment may mean that only one or two will do the actual experiment and

the others will be lookers on. On the other hand in some of the larger experiments, such as say a complete heat balance on a heat engine, a number of simultaneous observations may have to be made. This will require more students per batch. A good plan will be to have more experiments of a simple nature in the first group with only one student per experiment. The next group of experiments can have less number of more difficult experiments with 2 or three students per batch. The last group of experiments may consist of the larger experiments and each batch may have three or four students. As the students in each batch have to work as a team it is better to let them form their own batches.

Another point is about the nature of the instructions to be issued. Dependence on mere oral instructions has many disadvantages. It is impracticable to have one instructor per batch and hence many students will be left unoccupied while the instructor moves from batch to batch. The opposite extreme is where the instructions are printed in book form and each student provides himself with one copy. These books are often bulky, costly and wasteful. There is also a lack of flexibility in using a printed book which cannot be readily modified to suit the vicissitudes in the laboratory.

Further, however elaborate the written instructions, it cannot be a complete substitute for the instructor. A via media will be to have concise instruction sheets to go with each experiment by studying which the student will be able to make a beginning. The instructor can supplement these instructions orally as and when necessary. It may be an advantage to have duplicate instruction sheets which the student can take home with him to come prepared for the next experiment.

In preparing the experiments care must be taken to see that each experiment carries its own message so that it will give a chance to evoke the enthusiasm of the students. In other words the data must be capable of analysis leading to some conclusions. If due either to faulty instruments or wrong measuring techniques the results are misleading then the message conveyed is false and the student may be confused.

A practice that has to be discouraged is the repetition of the same experiments on different types of equipments. In defence of this practice the plea is often advanced that this will serve the purpose of familiarising the students with different types of equipments. This plea is not valid because the laboratory is hardly the place for teaching the complexities of equipments.

This is the task for the students themselves when they enter the profession. The laboratory has to devote more attention to the principles behind the functioning of various equipments rather than the details of their construction. Under these circumstances repetition virtually amounts to a mere padding up of the experiments list.

In general, while dealing with students at the undergraduate level, the preparation of the equipments required for the routine experiments and the main experimental set up for the same will have to be the concern of the laboratory staff and the instructor in-charge. The instructor in charge must check the equipments to see that there will be no major impediments and that the equipments will perform as expected, when the students report for the laboratory classes. If one experiment fails to function due to failure of the equipments it may interfere with the cycle of experiments and disrupt the work of the laboratory.

In this connection, I wish to crave your pardon for yielding to a temptation to refer to our own experience in this dear old Institution 35 years ago. With the best will in the world the instructor-in-charge could not get the obstinate engines in the heat engine laboratory to start when an experiment was due.

This was a reflection on the types of equipments then available. As the laboratory classes used to precede the breakfast hour sometimes these classes served only to increase our appetite for breakfast, after the heavy but unsuccessful manual exertions to get the engines started. Today's equipments are of course a far cry from the equipments of those days.

While the main experimental set up may be already in position there will be scope for the student to choose some of the instruments such as thermometers pressure gauges etc. Some guidance and check from the instructor may be needed in choosing instruments of the proper range and capacity. If the range is too low the instrument may be damaged and if too high the measurement errors may be too large and the experiments may be vitiated. It may be difficult for the student to calibrate each and every instrument used in an experiment. As a rule he must be furnished with properly calibrated instruments. Spring balances, pressure gauges etc. subjected to vibration may lose their calibration in a short time and they may have to be calibrated frequently to get proper results. The importance of calibration has to be brought home to the student.

When deciding the methods of measuring the quantities and the instruments to be used, consideration must



be given to the accuracy required and this requires that the end result is kept in mind rather than the quantity measured. Sometimes a large error in one quantity may have negligible effect on the result whereas a small error in another quantity may cause serious error in the result. For example consider the simple case of a break horse power test on an engine in which, let us say, the tight side tension is 200 lbs. and the slackside tension is 10 lbs. so that the effective tension, on which depends the horse power, is 190 lbs. A 20 per cent error in observing the slackside tension may cause this to be read as 8 lbs. causing the difference to be recorded as 192 lbs. or an error of about  $1\frac{1}{2}\%$  in the Horse Power. On the other hand even a  $1\frac{1}{2}\%$  error in reading the tight side tension and hence the same  $1\frac{1}{2}\%$  error in the final result. This indicates that in this example a 20% error in one and a  $1\frac{1}{2}\%$  error in the other have the same effect on the final result. A fluctuation in the reading of the spring balance on the slack side will have negligible influence on the result whereas a similar fluctuation in the reading of the tight side spring balance may completely vitiate the result and hence it may be worth replacing this spring balance by dead weights. This example shows the importance of taking care not only in the choice of the instruments but also in their proper disposition.

There must be a clear idea as to the actual data to be collected and which quantities are to be varied and which held constant. Plans should be made to collect all the data needed. Each observer taking part in the same experiment must have a complete and separate data sheet of his own. There must be a plan as to the number and length of the runs. Very often a certain minimum time will be required for conditions to become stable. If the thermal capacity of the devices used in the experiment is large the time required to attain stable conditions may be more. If the experimental set up is new, preliminary trial runs to decide the length of each run may be a necessary preparation for the smooth progress of the experiment.

Another point of importance in deciding the duration of run is the measurement of total quantities involved in an experiment. As an example consider the case of an experiment usually performed in the heat engines laboratory namely, an efficiency test on a steam boiler. If the boiler is a coal fired one the test duration may have to be a few hours to ensure that any possible changes in the amount of coal within the furnace or of water in the boiler are insignificant in comparison with the total quantities consumed during the test.

As the time available for any experiment is always limited and each run may take a certain minimum time, the number of runs may have necessarily to be limited. In planning the experiment this point is very often overlooked by the students. There is a tendency to collect a greater number of observation in the belief that a greater number of points will give a better graph. This is true only if all the observations are accurate.

Where observations are to be made at stated intervals it is better to record time by hours and minutes of the day. This will give a better perspective on the experiment. Any omission to record the atmospheric pressure or ambient temperature during an experiment may be capable of being subsequently remedied to some extent if the date and time of the experiment had been recorded. It will however be prudent for some observer to record the barometric and ambient temperature during each experiment since they are required directly or indirectly in most work.

When the experiment is not of a routine nature but is carried out in connection with research work or at post graduate level, the approach has necessarily to be different. Naturally there cannot be any dependence on instruction sheets or laboratory manuals. The students should make a thorough search of the literature. Although the

desired answers may not be found in literature, sufficient information may be uncovered for the best procedure to be adopted. There must be wide latitude for the student in the choice of the experimental set up, the instruments to be used and the procedure to be adopted. Meticulous care should be taken in calibrating all the instruments used in the experiments. In such experiments the equipments and instruments specially assembled for the purpose may have to be dismantled soon after and then it may not be possible to repeat the experiment. Hence special care must be taken to plan in advance so that all information that may have any conceivable use are collected during the experiment itself.

The actual conduct of the experiment, the analysis of the data and preparing a record of the experiment must be considered to be outside the scope of this paper devoted to preparation for experiments and hence these need not be elaborated here. There is no doubt however that some thought given to these while preparing for the experiment will be advantageous. For example the analysis and presentation of some data may be best done by the use of special graph paper. This must be readily available so that curves may be plotted, if necessary even while the experiment is in progress. The report of an experiment may consist merely of filling up data in a printed

form or it may be specially written up. Each may have some advantages and disadvantages. All these aspects could be looked into even when preparing for the experiment so that maximum benefit can be derived from the experiment.

#### DISCUSSION:

L.V. NOTHSTINE pointed out that there could be a discussion on each laboratory itself.

N.M. JANARDHANAN asked what sort of preparation is necessary for conducting experiments in a laboratory. He wondered whether the students should exercise their judgment in selecting the equipment instruments etc. or could the set up be given to them and they be asked to go ahead and find the results.

R. SAMUEL said that the preparation of laboratory experiments could be divided into six sub-divisions:

- 1) Planning experiments
- 2) Formulation of design
- 3) Equipment and instrumentation
- 4) Assembly of equipment
- 5) Observation
- 6) Analysis of results.

Senior members of staff could decide (1) and (2), (3) and (4) can be done by Junior members of Laboratory staff,

(5) can be left to the Technicians, and (6) should be in the hands of Senior members of the staff. In his opinion, the problem is, whether the students should be trained to go through all the processes or it is sufficient if he knows how to draw his own conclusions given the necessary data.

He suggested that technically qualified people need not be wasted in maintaining a laboratory. He said that such qualified people were needed only for (1) and (2) and that Diploma holders could be entrusted with other work.

A.S. RAJU said that it would not always be possible to simulate in the laboratory what was obtaining in practice. But he felt that an approach to it could be made. In his opinion it was not always possible to have an objective and plan the experiments.

S. NARAYANA BHAT said that one of the things necessary for the experiment was a note book in which the student draws the circuit diagram and notes the range of equipment. The student should draw the sketch of the equipment and do everything himself. He was of the opinion that the student must be encouraged to set up a small laboratory in his own home as a hobby. He suggested that experiments must be made interesting and attractive and that students should not be allowed to take their reports home.

R.P. ARTHUR said that certain amount of planning must be done to inform the students before hand so that he can come well prepared in theory. He suggested that every student must be well acquainted with the set up of the laboratory and its layout. Meaningless experiments should be avoided and they should not be introduced just to engage the students. He felt that the students must be trained to note other items like instruments etc. which might not have a direct bearing on the experiment.

U. SRIDHARA RAO said that the laboratory must be properly designed to attract people or students into the laboratory. He was of the opinion that proper foundations for engines, suppression of noise, decrease of heat etc. would help the students to spend more time in the laboratory.

A. SARGUNAM said that the end results or the aim could be specified and the student should be allowed to have his own approach.

S. PEER MOHAMMED asked, whether the workshops could be considered a laboratory. He doubted whether the objectives pointed out by the speaker were applicable to workshops. He felt that the present objectives seemed to produce workmen instead of engineers and that a different orientation was necessary.

S. SRINIVASAN said that there had been some discussion about who should conduct the laboratory class. In his opinion only the Senior Members of Staff must engage the students in the laboratory. He said that such had been the practice in the Electrical Laboratory. According to him, experienced staff only could know the various drawbacks of the student and cater to their needs. He was of the opinion that in Electrical Laboratories, certain amount of attention must be devoted to trouble shooting and safety aspects.

In his summing up K. Achuthan Nair said that at the Undergraduate level, part of the selection of equipment should be done by the staff.

He pointed out that the division of the labours of running a laboratory experiment as laid out by R. Samuel already existed and that it was implied in any laboratory set up. He felt that the students should go through the process of collecting data by experimentation and that it might not be desirable to ask the students to analyse the results from data furnished.

He agreed that the students must be given details of what he has to do in the next class. A few questions thrown at the students regarding his theory and preparation for the class would definitely help.

He felt that a class allocated for the set up of the laboratory would be useful. He agreed that it was



true that meaningless experiments must be avoided. He pointed out that the student got confused by such arrangement. The laboratory was not the place to study every complexity of a set up and that the spirit of the experiment must not be lost sight of. He agreed that a concise laboratory manual would be useful.

He felt that it might not be possible to give the aim and allow the student to have his own approach, especially with a large number of students. According to him, the re-orientation of the workshop training would be good. Their objective was to drive in the principles and not to turn them into technicians.

## ON THE PROJECT METHOD IN DESIGN COURSES

L.V. NOTHSTINE

Having experienced various project approach systems for achieving a learning situation it appears that the educational values inherent therein should cause us to give it further serious consideration. Many have used project mechanisms in many forms to get the desired experience on the part of the student. To a far greater extent, often the real learning experience may have occurred after college in an "on the job" situation. In some cases the experience may have been costly even though very well learned at the time.

When the academic program is complete and the grades are all recorded, what further information does the company interviewer seek to know? He wants to know how the prospective employee will fit into his organization or team of engineers. How is his leadership? What is his ability to make decisions? Does he depend on others? Is he capable of original work? In otherwords, his grades are okay but what are his real characteristics?

If the student is known well enough by his professor these characteristics may be accurately described as they exist. However, we may come to realize that the courses in his program were not particularly designed to develop any of the characteristics his interviewer is so keen about.

As subjects are outlined it is recognized that each contain so much "material". In the pressure for increased content in technical and non-technical areas in all subjects the students move through the subjects faster than ever before. The increased use of visual aids, demonstration techniques and better texts will improve our learning situations a great deal. In fact, by the time the engineering student is in the final year he will become very proficient as an assimilator of material. Tests for the assimilation generally determine the students marks in the courses. All too frequently we learn that the marks so obtained may have little index relation to the degree of success in professional life or the student's ability to do engineering work.

Motivations of the student should play a large part in the consideration of course design. A student who selects engineering as his field must certainly have some characteristics that can be recognized. He must have a desire to be creative for ours is a field of engineered creations. He must have felt a keen interest for analysis and design. He must have felt that if he can just learn and become qualified that he can do the work and would like the opportunity to try. The self-elected students of our field are ambitious, eager and desirous of the opportunity to demonstrate their ability to create and

design. Unfortunately, the curriculums have been so pressed for space that no home work is required as it has no effect in the present outmoded evaluation system.

Actually, we may see here a problem that is upon the entire field of professional engineering. We find it in many instances that others are planning projects and demanding the strategic and detail analysis of the engineer. Actually the engineer is the professional who is scientifically trained and mathematically prepared to be the planner and designer of complex projects and communities. The engineer planner is capable of the sociological aspects of planning as well as the scientific, statistical and mathematical aspects. Further he is capable of knowing the fundamentals upon which new engineering developments can be based which will give us greater progress in this field. Planning produced by non-scientifically educated people will certainly not provide the types of creative planning required by the modern day technologically based and oriented society.

Now let us turn to the discussion of project method for use in design courses. First, we are in bad straights for keeping the necessary design courses in the engineering curriculums. Due to the orientation of most subjects engineering students are in their final year before they really confront a design situation. All too frequently

they are then fraught with perplexity. Isn't there an equation where you can solve for "X" and come up with this design? As a rule there is not. The conception of a solution must come to the student first. This conception must be in form and in material and it must be followed with analysis for strength, use, and suitable appearance. Further it must be economically feasible and one must be able to construct it.

To consider all of these things and to be influenced by these things is to realize a much broader scope of ponderables than the usual classroom problem. Further, along with the present problem of economics in the teaching plant of the university, any step toward a project method of teaching cannot bear the error of increasing the teaching loads or in any way increasing the cost per student credit hour.

Many interesting features of such a system or of such varied systems of teaching can be evolved. Each will cause varied results and varied feedbacks. Most of all, development of the characteristics of the student shall be paramount. In some respects we recognize the desirability for an "internship" type experience for engineers. Some will achieve an excellent experience in the first position along this line while others will not. Actually a development of project method approach can be of

unequalled value if suitably developed in college courses.

Let me describe a project method as used in a civil engineering summer camp for a number of years and found highly effective. Two field parties of three men each lived in each cabin. A full complement of equipment was checked out to each party and in their keep for the summer. In the morning we had a lecture hour followed by a study problem hour. Then a second lecture on a different topic followed by the fourth hour period of problems related to the second lecture. In the t. afternoon the party chiefs assembled fifteen minutes early for the instruction and assignment of projects. The projects were designed to be of one afternoon duration. There were a few that went two afternoons and a couple that ran three afternoons. The point here is that the party chiefs received all the assignment. To accomplish the mission they had to relate the project to the other men of the party and decide on the method of attack as well as the equipment that would be required. This system turned out to be one of the most beneficial experiences for the men in camp. True enough some personality problems occurred and some by-passing was attempted but this worked itself out soon. The men found they could work with weaker party chiefs

and that the weaker men could be a great value. Really the weaker men were developing at a faster rate than the already experienced men. The system really is responsible for the great attainment of leadership experience. Further, it achieved a high efficiency in developing field proficiency that had hitherto been a problem.

The students are eager to face the challenge of making some decisions, selecting methods, and exploiting original situations with their personal intuitiveness. There exists the personal desire on the part of each man to prove himself and his ideas. The project method takes advantage of this natural force adding interest and challenge which make highly successful ingredients.

In other fields we can exploit the same technique. For instance, last fall the assignment was given to select a roof truss system for fixed dimensions of a building and to design the truss. This proved to be much more challenging and interesting compared to other problems where no decision could be made other than the analysis for bolt or weld pattern on selected structural shapes.

In the course introducing reinforced concrete design the student was assigned the problem of selecting a design which would use concrete to distinct advantage or would demonstrate an usual design in reinforced concrete. While other home assignments were being accomplished the students

had one week to submit their project name. At the time the project is named the scope of the task must be estimated by the professor to restrict the student effort to the limited time available. The tendency is to launch into the problem selected to the neglect of other subjects. Regardless of the extent of the design or analysis accomplished the total concept of project extent is the fascinating part which so engrosses the student. Here are some titles that came out of this assignment.

1. Dock with Adjustable Rise
2. Bowl Shaped Tension Bound Stadiums
3. Bridge Slab and Abutments
4. Bank Building - Two Slabs on Four Columns
5. Single Column Supported Roof Slab
6. Concrete Dome on Four Columns
7. Cantilever Dock
8. Prestressed Concrete Diving Board
9. Long Span Folded Plate Design
10. Concrete Tank for Manure Storage
11. Cantilevered Roadway on Retaining Wall
12. Concrete Arch Design
13. Prestressed Railroad Tie

For some of the projects selected the level of preparation was inadequate. References were given to the students to put them in contact with the proper



information. In some of the most difficult or advanced applications, the student handled a phase which he could do with limited research material on that subject. Actually the tendency to do something more elaborate than the capabilities is not seriously wrong. This is due to the curiosity and interest to do greater things. This curiosity is not satisfied with the short problem. It is likely that the curiosity is only encouraged and inspired to do more and better. Most students were actively interested in continued work after the assignment was complete and returned to them.

In the foregoing discussion each man had his own project and worked alone. However, he was free to get assistance from any reference material that could be obtained. In some cases interesting features were encountered and the topics discussed in class by the Professor thereby arousing class interest in an individual's project.

For some time I have had a recurring thought that there is another method of applying the project system in design. A scant outline of how it may operate will be presented. I feel certain that much scepticism shall be forthcoming. However, the experience mentioned with the "party chief system" assures that it could be implemented and perhaps with increased efficiency over

conventional class. I believe it is worth the venture to present it at this time.

1. Large classes can receive their formal theory lecture presentations in one large group.

2. The class can be divided into teams of three each including the project leader.

3. Projects are to be assigned to the team leader and the instruction given only to him. Thus only one third of the students would be in the project assignment lecture each time. Each team leader would receive the specifications for his project. The due date would be given as well as an earlier check point for a longer project.

4. Each sheet or report of (design or analysis) shall be signed by its author, checked and signed by another in the team and signed approved by the project leader for submitting.

5. Each new project is to be assigned and briefed to a new project leader. That is, the team members rotate leadership on projects and take turns cooperating with leadership. Two thirds of the team receives all communication on the project through the team leader. Together they work it out. The leader has no special privileges to absolve himself from fairshare of the work and responsibility.

6. Skill is required in selecting projects of suitable scope but within suitable time limits so that most projects can be accomplished by the teams within a week or shorter time.

7. Discussion, debate and test of ideas occur as a systematic process in this educational method. To maximize the educational process these features should be fully utilized. In many subjects conventionally taught the teacher only is developing this type of logic. The student should be required to be fully involved.

8. An analysis and check system can be implemented for full involvement of teams.

Courses designed and operated generally as in this brief outline will contribute greatly to the students ability to work with others. He will have experience on organizing a team as well as organizing an approach to a design project. He will have had a chance to develop leadership. Not only is this a chance but he is required to take leadership. He will have had to make some of the decisions. He will have to cooperate with others and work as a team. These are part of everyone's education requirement in today's society. It can be accomplished efficiently without increasing the cost per student credit hour and perhaps it may be done for less. The possible educational gain is certainly worth the risks involved.

TABLE A - CONTACT HOURS REQUIRED - B.E. DEGREE

	Average Entry Age Yrs.	Course Length Yrs.	Contact Hours
University of			
Madras	16½	5	6120
U.S.S.R.	18½	5½	5500
A.I.C.T.E.*	16½	5	5400
Europe	19	4½	4200
Australia	17½	4½	3900
U. S. A.	17½	4-4½	2500
India	18½	3-4	2100

\* All India Council on Technical Education.

TABLE B - INDIAN/AMERICAN COMPARISON

	Indian	American	Ratio I/A
Years of College	5	4	1.25
Days per year	200	150	1.33
Total Days	1000	600	1.62
Total contact hours	6120	2500	2.45
Hours-non technical	365	700	.52
Hours-technical	5765	1800	3.20
Lecture hours - Technical	3120	1100	2.83
Laboratory hours - Tech.	2400	700	3.42

## METHODS AND TECHNIQUES OF ENGINEERING TEACHING

I.O. EBERT

In introducing this morning's topic on methods and techniques in engineering education I would like to consider several broad aspects of the subject and leave to my colleagues a more thorough examination of a few restricted areas.

The purpose of engineering teaching is obviously to help our students obtain the background, knowledge, and tools necessary for successful performance in their future careers as engineers. In this statement there is an important point I would like to emphasize; that our goal is to help the student do these things. It is this point that we sometimes fail to realize. We have had a tendency to believe that the purpose of a teacher is to gather all important facts, stir them into a nice predigested mash, and pour them into the heads of the passively receptive students. The perfect student, in this view, is one who so successfully receives these unassailable truths that he is able to recall them verbatim when demanded on an examination. An illustration of teaching based on this premise is the lecture in which the instructor gives a monologue to a mute class. Sometimes, this method is even carried to the extreme in which the instructor

dictates directly from his notes - with suitable pauses - so the students can copy word for word. Hopefully, the number of instructors doing this is on the decline.

The laboratory programme in engineering and science is justified largely on the belief that one of the surest ways for a student to learn is through doing. If we believe this is true for laboratories, why do we shun this idea for theory classes? Instead of being a passive receptive the student should be an active participant in lectures. He should be encouraged or even required to take part by asking questions and by joining in discussions. An active student is an alert student. An alert student certainly is more receptive to learning than one who is physically present but mentally far away. There are many methods for making a class more alert. I will mention a few, you undoubtedly can think of more. A prime factor is change. If the class is so large as to preclude much active student participation, the actions of the instructor can keep the students alert. Clear enunciation with changing voice pitch, loudness, and emphasis can do much. An energetic instructor who makes blackboard figures quickly, moves briskly, looks the student in the eye and shows his own interest will have a contagious effect in improving student vitality - even immediately after lunch! With classes of under forty, active student

participation can be demanded. If students fail to ask questions or make comments voluntarily the instructor can force participation by asking questions of specific students (and the questions should not all be directed to the brightest students - nor to the dullest).

It goes without saying that to present a worthwhile lecture the teacher must study, organize and prepare a lecture; then - shortly before presentation - must restudy it. Even the most inspiring lecture loses vitality after the dust of a year or so collects. Such a lecture needs revitalizing through the replacing of old information by new rearranging, rephrasing and - most important - re-study. Among the worst teachers are the geniuses who feel they know a subject so well they can lecture without preparation. This is the primary reason, the discoverer of a principle (the original source) is a poorer person to teach about it than is a good teacher who understands it.

The above comments on improving presentation relate to the ordinary lecture - blackboard presentation, we all use. You are probably doing these things to some degree now.

Objective evaluation of his own techniques can lead to improvement of even the best teachers. Of course we each have our own individual characteristics so a

lecture which is inspiring when delivered by one teacher will probably fail when repeated by another. This is why, we must each prepare the lecture which is best for us. Getting back to the statement about helping the student learn: The primary responsibility in the quest for knowledge should rightfully be the student's. I am sure we all feel a moral obligation as well as a personal interest to encourage or even push the student into doing his best to meet the standards of the institution and to learn as much as he can. To encourage or push the students we in the U.S. have a powerful tool which is yet largely unavailable to you in India. This tool is full control by the instructor over the student's marks in the course. Thus, when the instructor assigns homeworks problems the student knows his performance helps to determine his course marks. If the instructor asks him a question or requests him to do a problem on the blackboard for the class this too may enter into his grade. The instructor devices and administers examinations whenever he wishes. These usually consist of several scheduled one-hour examinations spread throughout the term, a term-end final examination of two or more hours duration, and probably several unannounced quizzes. The periodic scheduled examinations insure that the student spreads his studying throughout the term



and the unannounced quizzes encourage him to keep up day by day between major examinations. I would like to emphasize that the questions on these examinations are entirely set by the instructor, he determines the scoring of the answers, he assigns the final marks, and no one (including his Dean or the University President) has the power to make him change the grade. Of course, he must be scrupulously fair and unbiased. If he does not mark fairly the students who compare results with each other, will discover this and request the instructor to correct the inequality.

This power of the instructor over marks is perhaps the greatest educational tool we have. During my previous stay in India I concluded - as has every other American who has studied your educational system - that the external examination, and its attendant evil, the unimportance of the classroom instructor in the determination of marks, is the biggest stumbling block in the way of progress for Indian Education. It is responsible not only for a large part of the inertia to modernization of curricula but also is responsible for other difficulties such as student indiscipline.

Before I conclude my remarks let me say a few words about some new experiments in teaching being tried at home. We are experiencing a student population explosion just as you are. We too are trying

to find seats for more and more students while the number of Professors and the physical facilities fail to keep pace. To make fuller use of our buildings and other facilities the school day is being extended into the evening hours and the previously leisurely summer period is being more fully utilized by offering a wider number of courses. Universities having terms on the quarter system are beginning to offer a full quarter's work during the summer; those on a semester system have initiated a "trimester" plan which gives three full semesters work in a year. Thus, an ambitious student willing to forgo his, summer vacations might graduate in three instead of four years. Since the faculty will be more fully utilized with these plans, a significant increase in faculty salaries is given.

Other plans to more fully utilize faculty revolve around the idea that a college student is mature enough not to need an instructor as a nursemaid (or should I say "ayah") and can largely direct his own studies. This means the instructor provides notes, assigned textbooks, gives periodic help, and administers examinations but gives very few lectures in the usual sense. The student may be helped by such devices or techniques as:

Programmed books  
Teaching machines  
Tape recorded lectures  
Visual aids, etc.

To further extend the talents of good teachers my University is making extensive use of large classes with smaller tutorial sections run by assistants. Widespread use is being made of closed-circuit television so the same teacher can meet several classes at the same time in different parts of the campus. Some of these lectures are even video-taped so they can be shown over at a later date. These techniques have been largely confined to first and second year courses and have not been used in engineering. This fall, however, we are experimenting with a device which transmits writing by means of a telephone connection. This will carry the blackboard message while a voice connection carries the lecture. So a post graduate course will be given in Grand Rapids 60 miles from East Lansing-at the same time the course is being given at the University. Return voice lines will permit the Grand Rapids students to question the East Lansing Professor!

I have touched on a number of topics in this talk, none of which is strictly limited to engineering teaching. The aim has been to stimulate thought,

discussion, questions, and controversy. If I accomplish one or more of these I will have succeeded.

#### DISCUSSION:

S. SANKARALINGAM said that the students must be given small project designs in his own field. It helps him to develop his creative thinking ability. The project work must be given during the I, II and final years. During the I year, 75% of the data required can be furnished and he wanted this percentage to be reduced as they move up to the final, year.

P.L. VELIYAPPAN felt that greater percentage of marks should be allocated for sessional work. He suggested that students failing in any one year must be able to study that year also after promotion to higher class.

N.M. JANARDHANAN said that if an examination was internal, the student got examined only in the quantum given by the teacher. The knowledge of the students would be limited to the limitations of the teacher. Hence he preferred the present system of examination.

In arranging project work, the student should be guided by experienced teachers. He asked **that** if the teacher was not well equipped for this task, how could they be trained.

P. PURUSHOTHAMAN suggested that student-teacher contact hours must be reduced to improve discipline and that "Engineers must be given a free-hand in planning and development of Engineering education.

M.N. NARAYANA RAO felt that they should lay more emphasis in the day-to-day problems of industry. The project work given may be those encountered in the industries even though they might have been solved by them. The students themselves could evaluate the project work done by them.

He said that self-educated student was almost absent in this country. The student got into a course purely for opportunities for getting a job easily.

S.T. NAGARAJA said that syllabus could be framed to suit available text books. He felt that reducing contact hours might not reduce the indiscipline in Colleges.

S. NARASIMHAN suggested that citing instances of records of past students, would stimulate good interest in the students.

H.G. SHIVASWAMY said that the students should look into the teacher as a guiding personality. If the teacher had the final say in the capabilities of the student, student discipline would improve. He suggested that some methods must be devised to make the student come

to the teacher for help and aid.

P. SAMUEL said that decision making quality is lacking in our society. We should allow the students to think for themselves and make decisions as they feel and like.

A. SARGUNAM said that if the project method is to stimulate original approach, creative thinking, team spirit and leadership among students, it would be necessary to reduce contact hours so as to give an opportunity for the students to spend more time in Library. He further suggested the introduction of project method in the pre-final year itself.

In his summing up I.C. PERRET said that in U.S., the curriculum was set up before the course was offered. The classes are large and they are taught by more than one instructor. These teachers got together and decided upon the text book for the course. He agreed that each teacher may have certain short comings. But if the teacher was too bad, the fact would be exposed as the students have the option to choose the sections handled by various teachers.

He felt that an increase in the proportion of class marks or sessional marks would help to make the student look upon the teacher as a guide.

L.V. NOTHSTINE suggested that if in the project work a large number of data were furnished, student might be allowed to choose only the data that he needed for the solution of the problem. He was of the opinion that they must teach the students that they must surpass the teacher. They must be taught to take what we have and make it better. The young teachers must be guided by the more experienced ones, and the students must be given opportunities to make decision. Engineering education is an education in itself and there should be a constant revision of the teachers' ideas and knowledge.

## METHODS AND TECHNIQUES OF ENGINEERING EDUCATION.

W.J. FIERLISEN:

An extract of the speech is given below:

According to Prof. FIERLISEN the Aids in instruction are: models, audio-visual aids like phonographic records, charts, maps, television, tape recorders etc. These aids are to help the understanding and retention of what they receive by instruction. One retains 10% of what he hears, 25% of what he reads and 50% of what he sees. Hence, teaching with aids or working models will produce higher retentivity.

He said that field study was important in working with real and natural things. Tours and inspections create a natural interest in the student. The instructor should visit the works before hand and prepare sketches for the students to note. He felt that in using models, great care must be exercised that students did not get wrong impressions due to reduced scale etc.

Still picture materials will be useful when long usage of the aid is required, during lectures, and that teachers can make their own slides with some aid from the institution. He also advocated the use of an overhead projector to supplement the lectures. Distribution of semi-notes to the students will relieve the



students of the burden of taking entire notes.

The motion pictures will help the students in getting into the inner aspects of a manufacturing process and films produced on co-operative basis with the industry will help in the instructions.

According to him Blackboard is a good teaching aid and it should be fixed at a proper place. Elaborate drawings on blackboards must be avoided. But instructional aids cannot be used to replace the instructor and they can only be an aid for better teaching.

#### DISCUSSION

K. ARUNUDAN suggested that before presenting films to the students, advance notice should be given to them with a preview if possible. Hence all classes should be provided with darkening arrangement.

S. PANDYANA BHAT said that the aim of the instructional aids was to make the students more attentive in the class.

Summing up W.J. FLEPPELSON said that many of the equipment needed for audio-visual aids were now made in India and that it must be possible in the near future to use these in India. He informed that most of the rooms in the Wisconsin University could be darkened and that most of the American Universities have audio visual departments. If instructions were made interesting there should be no student indiscipline.

## ROLE OF EXAMINATIONS IN UNIVERSITIES

C.P. RAMASWAMY AIIYAR:

Mr. Chairman and my good friends,

I am much indebted to your kind words in introducing me to this audience. I have been asked to speak to you on the role of examinations. Now, there are two types of examinations - one may be described as Internal in character and outlook, and the other external. The Internal Examination is generally resorted to by the head of an Institution for the purpose of testing the progress from time to time of the alumni of that Institution. Any ideal scholastic or educational centre in my opinion, should be residential in character and partake essentially of the nature of what was in our ancient Gurukula type of institution. The formal examination was not really thought of in a Gurukula or in any of the medieval universities of Europe. Students chose the teacher and gathered around him and the Universities thus came into existence. I need not remind you, of the history of the ancient Malanda, Taxila or the Universities of Europe and their character. It was not a matter of class rooms, laboratories and libraries. It was the case of a large number of eager, adaptable and enthusiastic students coming near, close in every way, to a teacher of eminence.

It was the teacher who was the nucleus or the centre of the old type of university and the students maintained themselves and also maintained the teacher. Both in India and in Europe people in Oxford, Bologna, Paris, especially Paris-gathered round the teacher in that way, and out of that, gradually developed a gathering of more teachers and more students and the universities of the present day, are the successors of those universities. In an ideal residential institution, there is really no scope for an examination because hour after hour, the teacher and the student will be in contact and discussing various problems. In this connection, I desire to place Cardinal Newman's five points on Universities. He said, it did not matter if a university had buildings or not, it did not matter even if the university had a great library but it did matter that it had impressionable young men coming in contact with an inspired personality and thus his mind and his aspirations sublimated. That was the residential type which was in vogue in the old days in India and so were the medieval universities in Europe to some extent. As time passed, a situation developed when the teacher did not know the students, and the instruction imparted to the students was only a reduplication of text-books. As institutions progressed in that direction, examinations became

important from the point of testing progress, of finding out what particular career suited to a particular student. Thus, examinations became more or less compulsory both to the teacher and to the student and so they went on. My own opinion, regarding the system of internal examination is, that for two important reasons, i) to examine their progress in their day to day performance in the class and ii) to help to get credit in the moderation, they are necessary. It is a common phenomenon that although students may have performed well in the class from time to time, they may not acquit themselves well in the annual examination, due to their emotional imbalance, or some kind of psychological excitement or nervousness. It is always preferable to have a co-ordinated system of examination taking into account the performance in the class month by month along with the results of the annual examination so that even if a student does not fare well in the annual examination, the performance in the internal examination would help him. For this purpose, real contact with the teacher and t ught is necessary. If there are a large number of students in the class-more than 50-it would be difficult for the teacher to pay proper attention to the imparting of instruction to every student. This is one aspect of the problem. But the other aspect with which we may be concerned with is what is called the public examination. Public examination is original

in character. It compares the achievements of the pupils of every scholastic section and the question of setting up a paper which has to be answered by pupils of different institutions of different intellectual disciplines subject to the teaching methods, and mode of approach to the different intellectual acquirements and aptitudes. Whether that kind of public examination is desirable and whether it serves the purpose, has to be examined. Public examinations like F.U.C., B.A., B.Sc. are purely external. The pupils undergo the same kind of disciplines. One of the great difficulties of such an examination is that the question paper cannot possibly cover the whole field. From my personal experience, and the experience of our neighbours, it is seen that with a certain amount of regulated cramming during a month or two, they may come out successful if questions, all from the portions crammed are asked. If misfortune overtakes them, and if the crammed portion does not come, they may have to fail. There are certain advantages in the answering of yes or no questions as in the United States. But they have their limitations. After all, the student should be able, not only to think on the subject matter, of the examination but also be able to organise his thoughts and express them coherently. For many years now, I have been speaking on this subject. I have stated that it ought to be possible for an examination

to be conducted with complete liberty - each student to take as many books as possible in the examination hall. So far as India is concerned, there is over emphasis on text-book knowledge. In the olden days, no doubt, Vedas and Upanishads, were memorised by the students. We now inject textbook knowledge in the intellectual frame of the students and expect them to display or show results - and in this I want a different approach.

My own idea is that teaching should no longer be confined to textbooks but should be done in a more general way. The examination should concern with the subject rather than with a particular textbook and further enable the student to fortify himself as an authority. In subjects like Mathematics, reasoning and comprehension of the student are more important than the acquaintance with the subject. In short, a new orientation should be given to examinations for evaluation of knowledge.

## DEVELOPMENT AND GROWTH OF INSTRUCTORS

LEO V. NOTHSTINE

The first quality of the potential instructor is that he must be a capable student himself. It is not necessary that he borders on genius. In fact, a genius should not be selected as his talents should be used elsewhere in research. Further he may not understand the usual problems of students. It is necessary that a suitable selection system be used for choosing or admitting new people to engineering teaching.

Teachers should be sought at several levels. For instance it should be desirable to offer starting positions for those with a B.E. to teach 1/4 time and study for M.Sc. 3/4 time with a suitable stipend for this service. By such a system the young teacher should be advancing in his field as well as getting experience for teaching. Suitable subjects for his level would be chosen for him to teach and be supervised by a senior member of the staff. This of course can occur in M.Sc. qualified colleges of which more are needed.

Another starting position should exist with suitable salary schedule for the M.Sc. holder. It should be presumed all new staff shall have attained or will attain the M.Sc. degree in a reasonable time for

undergraduate teaching. Of course there are those teachers who have taught for many years and have experience and knowledge equivalent or above the M.Sc. degree holder and have demonstrated the qualities of great teaching. They must not be displaced or wasted by being replaced by untested men with new credentials.

Further, there is a need for B.E. holders with 5 to 10 years experience who can return to the colleges for teaching and study to complete the M.Sc. degree. A program with suitable salary schedule should exist that will provide some of these qualifications also.

From the administrative point of view it should be desirable to have a staff of high quality. High quality can be defined as being of complex order. Do not expect to build a good staff on one set of specifications for all men in all positions. Some staff will have high attributes as scholars and researchers. Some staff will have talents as excellent teachers and very capable of handling students. In fact each staff member should be evaluated on his very own merits and not on how well he fits an arbitrary specification. The very difference in qualities of a staff may be the best ingredient for a very successful staff for the training and education of the new engineers. Some may be quite theoretical



while others may be able to give much interpretation between the mathematics and real materials and operations. Great emphasis should be given to the developing of each man's talents. For some, this is in the field of creative design. For some, this is in the field of theoretical analysis. Others may do research and write while there are some excellent teachers who read the journals and make the classroom a lively place of learning. Do not try to measure all teachers by the same meter stick. Each College should judge its needs by the talent that it possesses or fails to possess.

The new staff member should familiarize himself with the syllabus for the courses he teaches or assists in teaching. He is a very important man in his institution for his students will ask him many questions while they seldom risk asking the senior professor the same question. He should be most willing to receive questions and give good answers as far as he can and seek better answers. His importance increases if he eagerly studies the work with its new problems as presented by his students. If he answers truthfully and also seeks answers that are not already known to him he develops with his position and with the students who study under him. Each new batch of students enrich his experience and increase his value as a teacher.

Arrogance and aloofness in a teacher should not be tolerated. These traits are an indication of insecurity, lack of proper knowledge, and an inferiority complex. These affectations are used to cover up weakness and the desired qualities of patience, understanding, and helpfulness. No one can be expected to answer all questions. But almost any one can be helpful by assisting in finding or directing the student to the answer. But there is also the sin of giving directions that are not helpful. One who is genuinely helpful usually has the questionable reward of being asked more questions. This can be a form of the measure of success in the general acceptance and respect of students. Do not confuse real respect with false respect, fear or sense of duty. Real respect can cause a student to try to emulate the fine qualities he sees in a man. At this point it may be admitted that the problem of respect may have a complex connotation in India as compared to America. It may not mean exactly the same thing in both cultures. However, the developing teacher must seek success in developing the minds of students and thereby he achieves greater understanding and development himself.

This development does not come automatically. It comes from continued study, varied teaching approaches and following up the details constantly. How can a

teacher instill the desirable quality in a student if he does not develop and demonstrate the same qualities himself? As he practices these qualities he shall grow in stature with each batch and as long as he practises he will continue to grow. When he decides that some of the details of his work are beneath him so that he stops pursuing the answer and only passes over it or omits it, then he has stopped growing and developing as a teacher.

The rate of development of good instructors is very dependent upon the working conditions of his College. He needs an income that liberates his mind from the desperate problems of rent, food, clothing and medicine. His income should give him some self respect and his position should hold sufficient opportunity to earn promotion and advancement in future years. Variable rates of promotion depending upon ability and achievement must prevail. This will give sufficient incentive to raise the challenge for active competition. Without incentive where is the challenge? Man's natural tendency is to do a very worthwhile and good job of the work at hand. The administration must provide the incentives.

The physical plant should be in keeping with the atmosphere of the job to be done. Clean restrooms, clean laboratories and class-rooms, good lighting well placed,

and good ventilation are some of the requirements. Budgeted funds should exist for improving all departments annually. The department heads should be constantly aware of improvements to be made and by no means stand still. They should constantly require the new and younger staff to submit ideas for physical improvements in the teaching plant and the teaching system.

In the laboratories there are opportunities to use colour code on machinery and apparatus, improved chalk, boards, mechanical pencil sharpeners, reference materials and suitable writing space so the report can be prepared on the spot. The teacher should try to discover new laboratory procedures and experiments that provide greater learning experience than the old problems. Then some of the older problems must be up dated or discarded. Responsibility for the conduct of the classes and the subject material must come from within. The details of the subject itself must rest with the teacher. He who shrugs the details of this responsibility off, as belonging to those higher up, is shirking his duty.

The teachers should use English and insist that the students use good English. We have referred to English as the "International Language" and well it may be. The effort must be made constantly and unify pronunciation,

for universal understanding. Much could be done in this respect in many formal and informal ways.

In technical language symbols should be standardized for clarity and understanding. Avoid alteration of greek letters for the same meaning. Present standard equations in the same form each time. Use simplification as the primary teaching tool. Reduce compound problems to their simple elements and weave the components together in logical sequence to give the complete story and in sequence for understanding.

Young teachers as well as those who have much experience can benefit by having informal seminars and discussions on topics of interest. These topics can be old routine ones or on some latest development. They can also be on any current problem that a member of the staff may wish to raise. Regular sessions on study in new areas may be introduced to staff who can take turns presenting material, discussions and visual aids on the subject in question.

There is need for a south Indian association of Engineering Teachers. The purpose of the association would be to assist and encourage young teachers and to promote good engineering teaching at all levels.

Engineering Education needs such an association in India. This association would be an organization for publishing papers, making studies and reports and holding annual as well as local meetings for discussion and debate of engineering education topics from which the shape of engineering education for the future can develop. Active participation in such an organisation should be mandatory for the engineering teachers. It should be made clear that the organization is primarily for those in active teaching and not the administrative people. Otherwise administrative people could dominate the offices and activities and cause the association to lose effectiveness for developing young teachers.

At all levels of staff there seem to be a very large chasm in general between engineering teaching and professional practice. This is a serious drawback and efforts be made to bridge the gap between education and the outside world. It is recommended that efforts be made continuously to cause practising engineers from industry and Government to return to the college for short learning sessions on new and varied developments, special lectures and educational programs. Visits and field trips for staff to engineering and engineered projects for first hand experiences are of prime importance.

From an increased activity as the foregoing it is hoped that the college could get some research project started and sponsored by industry or government. The staff should be encouraged to look for ideas that could possibly have a benefit to industry and thereby make a proposal that would be acceptable. Should the staff become partially engaged in research and special problems then it must be expected that the strength of the staff should be increased. Obviously, the vitality and effectiveness of staff could be greatly increased should this type of activity develop.

When a teacher of a professional subject becomes a recognized expert he may have opportunity to do consulting. When done in moderation, consulting is very beneficial to the teacher, to the students and to the college. Misuse of consulting privileges can only lead to loss of consulting privileges for all. Therefore a carefully laid out program should be laid out with incentive strong for the man who must do the work. The present 50% fee basis is probably a strong deterrent to those who would be doing design work. The policy on consulting probably could be reviewed and a more optimistic program installed.

Seminars and institutes such as this Summer School on Teaching Methods are of general good for those who

participate. Meetings within each department at a college should have more specific benefit and be more applicable for the young teacher. Regional meetings have benefits for the mixing of ideas and solutions to problems. Local meetings apply to the local details of implementing methods. Both kinds are needed. Unfortunately only limited participation can exist at Regional meetings. One hundred percent participation can occur at local meetings and department meetings.

While there are many facets to the development and growth of engineering teachers this paper only treats some of the more obvious factors. The main features to consider as individuals and as institutions are the ones that are catalyst to more and greater development of the individuals on the team of engineering teachers.



## DISCUSSION:

T.R. DAS said that there is isolation between industry and technological institutions. There must be a revolutionary change in the administrative set up. The writing up of confidential reports must be abolished. This will make the staff feel free to ventilate what they think. He wanted promotions to be based on faculty recommendations.

S. NARASIMHAN said that development and growth fitted an S curve with respect to time. Each method produces a rapid rate of growth upto a certain time, and beyond that it becomes static. He warned that too many committees might lead to waste of time.

S. NARAYANA BHAT asked whether it is advisable to employ retired personnel as is being done now, because of the staff shortage.

R. SAMUEL felt that growth and development of instructor took time. The teachers should not become teaching automats, and they should grow as they expect the students to grow.

Summing up L.V. FOTHSTINE said that teachers should present a united front and that the developing instructor should be able to see the work that he has done or achieved.

## TRENDS IN THE FIELD OF ENGINEERING EDUCATION

V.V.L. RAO

### INTRODUCTION:

In this paper, I would like to concentrate on four aspects of "Engineering Education". They are:

- i) What are the short and long range objectives?
- ii) What are its patterns and contents?
- iii) How often does this pattern change in any country?
- iv) How does an engineer refresh his knowledge after he leaves college?

An attempt is made to answer these basic questions. To help answer them, I have surveyed the trends in engineering education in:

- i) the U.S.A.
- ii) the U.K.
- iii) West Germany
- iv) the U.S.S.R.
- v) India

We can start with the following definitions which serve our purpose:

"Engineering is a profession, in which a knowledge of the mathematical and physical sciences gained by study, experience and practice, is applied with a judgment for utilization of the materials and forces of nature".

"An Engineer", is defined as a "person, having the training and experience required to perform specialised duties in a branch of engineering".

We must now distinguish "Engineering" from "Science" and "Technology". Broadly, Technology is application of an engineering principle. However, there is fundamental distinction between an "Engineer" and a "Scientist". An Engineer generally designs, constructs, operates or supervises whereas a 'scientist' seeks to unearth new knowledge, new principles, or new materials. As regards producing an engineering graduate to make useful contributions to the development of the country, we have to consider the professional aspects of the engineering education together with the place of : (i) Humanities, (ii) the Basic sciences, (iii) Social and biological sciences, both in the education and training of engineers. The task of compounding all these elements into our so-called 5-year Integrated course is an urgent problem. The importance of the humanities and social sciences will have to be recognised from the lowest to the highest levels in engineering education, because in a technocratic world, society has to rely more and more on engineers for leadership both in business and affairs of the State.

Engineering at one end is highly theoretical in character, while at the other end, it can be wholly practical. The wide spectrum of engineering activities range from: research, development, design, consulting production, construction, sales and last, to 'Technical Education'.

The following instances will show the difficulties in the tasks of education for an engineering career, because of the diversity of needs and opportunities, both educational and professional.

i) It took only a decade for engineers to produce, on a mass-scale, jet aircraft, after the basic ideas of jet-propulsion were given to the world by Sir Frank Whittle. Almost overnight many Mechanical Engineers, experts in the design of piston engines, found their knowledge almost useless, in view of Whittle's work in early 40's. Now, rocket-propulsion and nuclear propulsion threaten to compete with the jet-engines and jet-aircraft.

ii) It took only 5 years for the mass manufacture of transistors after Schokley, Bardee and Brzttain perceived what future solid state physics held for semi-conductors. As the transistor has been fast usurping the place of the vacuum tube, electronics

men all over the world were faced with the need of updating their knowledge.

iii) Developments in 'automation' have changed values of human labour.

iv) Developments in 'aeronautics' have annihilated both time and distance.

v) Developments in 'space-technology' and 'nuclear armaments' have changed both the roles and responsibilities of national leaders.

#### WORKS FUNCTIONS OF ENGINEERS:

In order to get a broad engineering course, we have to first consider broadly the work-functions of engineers in our present era. The two broad categories are:

i) To conceive from pure abstractions, new and superior devices. This implies a talent for improving the existing devices with a view to making more sophisticated ones.

ii) As construction and maintenance engineers in assembling, operating machines, etc. they are custodians of technology. Our country needs this type of engineers in great numbers in its development. They too must have a high proficiency in Mathematics, Physics and Chemistry and related sciences but not to the same depth demanded of the persons in the first category. For the latter

category, a Bachelor's Degree from an Engineering College should suffice as far as academic training goes. The rest is to be picked up on the job.

#### THE CREATIVE ELEMENT AND NEW CURRICULUM:

To develop students with creative ability, we want curricula, which will unravel the basic findings that scientists discovered by their thinking, so that engineers may know precisely not only the 'WHAT' and 'HOW' but the 'WHY' of it.

Next we want a syllabus to teach both 'science' and the 'scientific method'. This means we must devote sufficient time for both "analysis", and "synthesis". In short a true 'engineer' is a 'scientist who not only dreams but realizes his dreams'.

#### A TECHNICAL UNIVERSITY OR COLLEGE - ITS FUNCTIONS:

Next, we must consider 'what is a University?', and its functions relating to "engineering education".

A university essentially comprises three limbs: (i) the taught, (ii) the teachers, (iii) the 'human-hardware' or the administration. Needless to say that the first is the most important item since without students there would be neither faculty nor the administration. An engineering college should be rather a "think factory" than a factory, where engineers are produced. Attention should be concentrated on how to generate new ideas, new

philosophies and new doctrines with a view to meeting the challenges of the future as well as the present. It should not merely be confined to teaching facts from textbooks, written some decades ago, which are still used by many. Therefore, there is an urgent need for modern textbooks, incorporating the results of post-world war II research in science, engineering and technology during the past 20 years.

There is also the question as to who should teach an engineering student at various levels? Often, a very good research worker may be a very poor teacher, and vice-versa, especially at the under-graduate level. Sometimes comprehension is made difficult for the under-graduate student, if only D.Sc's and Ph.D's are appointed as teachers at under-graduate level, because often it is difficult for such a teacher to step down, as it were. But, graduate and post-graduate teaching should be done by only those who have done research or shown competence for research because the building of such courses and schools have to be done with knowledge springing largely from their own research programmes.

#### NEW HORIZONS IN ENGINEERING EDUCATION:

At this stage, I mention a few recent developments, which may be introduced at various levels both in the under-graduate and post-graduate engineering education.

i) "quantum mechanics", a working tool in many engineering fields.

ii) Processing of information through the (a) "Information Theory", influencing the design of many communication systems, and (b) "Electronic Computers".

iii) Processing of energy, e.g. (a) Solid State devices, (b) Plasma, (c) Cryogenics and (d) Magneto hydro-dynamics.

iv) Processing of materials: (a) Molecular engineering and (b) Biophysical engineering.

Some new horizons in engineering education must be thought of. These are based on the following concepts, viz.,

i) Methods of extending communication between :  
(a) man-to-man, (b) man-to-machine, and (c) machine-to-machine.

ii) Energy exploiting creatively and unconventionally:  
(a) Food synthesis, (b) plasma, (c) technology of the materials of the world. This is a huge problem and constantly both scientists, engineers and technologists are devising new range of products and materials (natural and synthetic) and almost to any particular specification required for any particular purpose.

iii) A better knowledge of the materials of the world he lives in.



iv) Man has been constantly striving for greater mobility for himself, raw materials and finished products. Materials required for the industry also have to be brought or taken from one part of the world to another. This topic of mobility leads to a new dimension in the role of the engineer of to-morrow. Therefore, these four concepts must be taught at a broad level to engineering students.

#### TRENDS ABROAD:

Here I will limit myself to (i) the U.S.A., (ii) the U.K., (iii) West Germany and (iv) the U.S.S.R. Owing to our long association with Britain, we modelled our engineering education after the British pattern, but always with a time lag. In recent times as a concomitant of the various aid and collaboration schemes we are considerably influenced in our pattern of technical education by the other three countries also, particularly, the U.S.A.

i) the U.S.A. : A substantial portion of the engineering curriculum in the U.S.A. is devoted to : analysis, synthesis and design problems requiring a good background in the basic sciences, the engineering sciences and the social sciences. For nearly half the students, who complete an undergraduate engineering course, their academic training stops with that and they take up jobs. The other half go to graduate schools as fulltime or part-time students.

It is thought that the number of undergraduate engineers in the U.S.A. will increase in 1970 from the present level of 34,000 to between 45,000 and 50,000. About 25,000 students proceed annually towards the Master's Degree. About 20% of those who receive the Master's degree proceed to the Doctorate.

One may ask whether the traditional classification in engineering schools (aeronautical, chemical, civil, mechanical, electrical, metallurgical) has become obsolete. There is evidence to suggest that, this is the case to quite an extent. "Space Technology", "Industrial Engineering", etc., now offered as major disciplines at many places in the States to-day were almost non-existent till recently. This only shows that curricula would have to be planned according to the broad national problems that lie ahead in engineering.

The past few years have seen many rapid and major changes in engineering curricula in the U.S. These trends are:

- a) A reduction in the number of hours devoted to engineering drawing and graphics.
- b) A reduction in the number of shop and laboratory courses.
- c) Increase in the level of required mathematics courses.

d) Increase in hours required for basic science courses; extra Physics recommended as technical electives.

e) Reduction in the hours devoted to synthesis and design.

f) Extra hours required in the Social Sciences and humanities.

From the above trends, it is clear that the original definition of 'Engineering Education', has deviated a lot from the definition of 'Engineering' and the aspects of a professional engineer. The emphasis has shifted towards the realms of the mathematical and natural sciences. That is, they are de-emphasising the distinguishing marks of the profession and building in more of the attitudes of the scientist. This trend is partly based on the belief that, if only American engineering graduates had more science, the modern complex engineering problems could be solved more speedily and exactly, by analyses alone. It is also partly due to the fact that engineers in the past have not always made enough efforts to obtain the available knowledge of the physical sciences that may be used to advantage.

ii) The British Technical Education System. The current British pattern of technological education is based on (i) the Universities, (ii) Professional institutions, and

(iii) Technical Colleges. Here a distinction must be drawn between "Technical" and "Technological education" as understood in Britain.

Technical Education is instruction in any subject applicable to the purpose of industry, agriculture, trade or commercial life and practice. The term is applied to the education of persons, who are to be technologists, technicians and craftsman. Technical education is being organised in the U.K. in four types of colleges at different levels: (i) District, (ii) Area, (iii) Regional and (iv) Colleges of Advanced Technology.

Technological Education is usually restricted to a more advanced level where fundamental scientific principles are more strongly stressed. A college of Technology does work at the University level (e.g. at Manchester) and forms a constituent part of a University. A number of colleges of Advanced Technology (called CATs) have also been set up and these run courses for the Diploma in Technology (Dip.Tech.) and the Membership of the College of Technology (M.C.T.), both of which are high-level awards.

Dip. Tech. is at the level of a University honours degree and the M.C.T. is equivalent to a University Ph.D. and is awarded to students who complete a substantial programme of work, concurrently in industry and a college,

which leads to the solution of a problem of value to industry. The National Council for Technological Awards was set up by the Minister for Education in 1955 as an independent, self-governing body with the power to confer national qualifications, like the Dip. Tech. and M.C.T.

In most of the British Universities, the engineering course, leading to B.Sc.(Engg.) or B.E., is of 3 years' duration. In 1950's for giving technical education at a high level, it was considered that, apart from these Engineering Colleges or departments of Engineering in the various British Universities, a new type of college, called the College of Advanced Technology, should be set up.

Manchester provides the only first degree course in 'Technology': B.Sc.(Tech.) at a British University. Cambridge and Oxford still give it as B.A. degree in 'Mechanical Tripos'.

There are 33 important professional institutions in Great Britain, some of which are incorporated by Royal Charter and Membership of the top Engineering Societies is highly valued.

iii) West Germany: In West Germany, there are 8 Technical Universities called "Technische Hochschule". Each year, about 5,000 students of the 55 thousand students at the 8 "Technische Hochschule" (T.H.) obtain their degree of Diplom Physiker, Diplom Ingenieur, Diplom Mathematiker, etc.

In T.H. the Professors alone lecture. The Professors and other members of his department are taken from industry. The benefits of industry so formed contribute greatly to the success of the T.H. A man from industry will be able to teach the students both the design and application aspects of the industrial products. The average student arrives at the T.H. at the age of 20 and takes  $5\frac{1}{2}$  years to gain his degree called 'Diplom Ingenieur'. The next degree is a Doctorate. However, about 5% of such students stay on to conduct research on a fixed salary. After about 6 years, at the age of about 36 they leave the T.H. and then go straight to the industry and take very responsible jobs.

The idea of getting Professors from industry is very difficult to implement in India, because industry offers higher salaries and other benefits. Even the revised salaries of Professors in Technical Institutions will not attract them from Industry.

iv) The U.S.S.R. : The Ministry of specialised Secondary and Higher Education with headquarters in Moscow is the control centre for the technical school system in the U.S.S.R. In the schools of basic general education (7-year incomplete Secondary or 10-year complete Secondary), the Russian student first of all acquires an

educational background with stress on Mathematics, Sciences and work practices. The curriculum for schools in basic general education would include a study of the Russian Language and literature, mathematics, history, geography, biology, physics, astronomy, chemistry, a foreign language, physical culture, general and technical drawing and even singing.

In addition to the above, the student is required to qualify in actual work-practice, which contributes to the Soviet Economy. In rural areas, the work-practice is usually agriculture and the use of agricultural machinery. In urban areas, it is in industrial production.

The 'Technicums' are a speciality of Russia. They are a part of the specialised secondary school system, producing the technician for the expanding economy of the country. Out of the 3,600 specialised secondary schools, 1200 are Technicums.

A recent and broad development in Technicums is a system of part-time evening attendance and correspondence school training. About 50% of all Technician enrolment are in these latter two types of training programmes. In the case of correspondence training, an attempt is made to provide equivalent full-time education by requiring such students to leave their work in industry for certain periods in order to do laboratory work in

Technicums. Technicum education plays a significant role in the Russian Economy.

The Technicum curriculum is broadly divided into 5 distinct parts. The student has to study political economy and the elements of higher mathematics in the area of general education. Foreign languages - English and German - are optional. The technical subject matter includes: Technical drawing, engineering mechanics in the 3 phases of theoretical mechanics, resistance of materials and machine parts. The 3rd cycle of special training consists of subject-matter, which is distinctly in the area of the speciality for which the student is preparing. The 4th area is physical training. The 5th area deals with practical occupational experience and training obtained by working in an industrial enterprise related to the Technicum and the preparation of a diploma subject. Every student of the Technicum (including Correspondence and evening courses), must conduct an original diploma project and submit a report. He has to collect data in two months and in other 6 weeks he has to write the report. The diploma project appears to be the final examination, applying the education and training the student has received to some concrete industrial problem.

The major full-time day enrolment is from the 7-year school rather than the 10-year school. It is



interesting to note that nearly 40% of the Technicum students are women.

A prominent feature of the Technicum level of training is the constant encouragement of workers to pursue further study, either through the enrolment in evening classes or by correspondance. Education, in general, in the Soviet Union, is free of tuition fees.

It would appear that, in the Technicum, the student is exposed to the way of life he can anticipate upon graduation. He gains works-experience and is exposed to the arts and entertainment. He is encouraged to develop physically and also take part in the political system of his country.

(In recent times, in the U.S.S.R. each year two or three times as many scientists and technologists graduate as in the U.S.A. and the production of qualified people is accelerating throughout the current decade. With only half as many graduates as the U.S.A., the U.S.S.R. has greater number of professions in engineering, and other fields of applied science, and the Soviet rate of growth in these fields is more than twice, that of the U.S.A. U.S.A. produces about 90,000 engineering science and applied science professionals each year and the Soviet Union's production is

1,90,000 annually. It was estimated that in 1960's would reach 2,50,000 annually, more than twice the rate for the U.S.A. In terms of quality, Soviet professional higher education in most scientific and engineering fields is atleast equivalent to and sometimes more than in the U.S.A. or Western European institutions of higher learning).

iv) India:

A survey of the needs of the country as a whole in the field of higher technical education began with the establishment of the All-India Council for Technical Education in 1945. The Committee, under the Chairmanship of Sri M.R. Sarker, advised the Government to provide facilities for advanced technical education with a view to meeting the problems of post-war industries. This committee recommended the establishment of 4 Higher Technological Institutions (H.T.I.'s) in the four regions of the country with a total capacity of 2,000 under-graduate and 1,000 post-graduate and Research students. The fifth I.I.T. was established at Delhi, with British assistance.

Further progress in technical education was the establishment of Regional Engineering Colleges in most of the States during the Second Five Year Plan. By 1965, fifteen such Regional Colleges have been established, one in each state.

Engineering colleges established during the First and Second Five Year Plans had a normal admission strength of 100-120 students annually. The present trend throughout the country is to have bigger institutions so that per capita cost is reduced considerably. The average admission strength in the Regional Colleges now established is 250. Very recently it has been proposed to increase the admission strength of institutions earlier from 120 to 180. Some of the older institutions like Guindy, established in the last century have already got admission strength varying from 350 to 400. So, at the present stage of development, in India there are six different types of Engineering or Technological Colleges or Institutions:

- 1) The Indian Institute of Science, Bangalore and the Indian Institute of Technology.
- 2) Two Engineering Universities: (a) Roorkee and Jadavpur.
- 3) Fifteen Regional Engineering Colleges
- 4) Govt. Engineering Colleges in the several States of India.
- 5) Private Engineering Colleges in the several states of India.
- 6) Other private institutions coaching for A.M.I.E. etc.

(1) and (2) give B.Tech. or B.E. and also post-graduate qualifications like M.E., M.Tech., Ph.D., and D.Sc. (3) and (4) basically give B.E. degree and some even post-graduate courses leading to the Master's Degree.

The main branches in which Engineering Colleges give Bachelor's degrees are: **(1) Civil, (2) Mechanical, (3) Electrical, (4) Telecommunications, (5) Metallurgy (6) Chemical and (7) Aeronautical Engineering.** Only the Madras Institute of Technology, which admits B.Sc. boys, has four rather unusual faculties, leading to Dip.M.I.T. (declared equivalent to the B.E. degree by the U.P.S.C and most State Governments). These faculties are: (1) Electronics, (2) Instrument Technology, (3) Automobile Engineering and (4) Aeronautics. M.I.T. courses are of 3 year's duration.

No Engineering College in India gives a B.E. degree in the first three faculties. That way the M.I.T. courses are unique and its diplomates get jobs in industry readily. Of late, some engineering Colleges have also started a 3-year B.E. degree course for B.Sc. passed boys in the traditional branches.

While framing the syllabus of the 5-year Integrated B.E. course, the AICTE has realised the growing importance of mathematics and science content at the under-

graduate level and so recommended mathematics to be taught for 4 years, Physics for 3 years and Chemistry for 2 years. Basic Electronics is made compulsory even for Civil branch students. All the M.E. courses have now a course of 'Instrumentation' and advanced mathematics and materials technology as compulsory subjects.

Thus, India has kept in view the modern trends in the field of Engineering education in the West, particularly the U.S., and has constantly been revising its syllabus to include more of mathematics and physical sciences and basic tools like: 'Electronics', 'Instrumentation' and 'Materials Technology'.

Frequently, we hear that our engineering courses in colleges should be reoriented so that they may have 'industrial bias' which can be achieved only by courses like the "Sandwich courses" in the U.K., and West Germany, and "Co-operative courses" in the U.S.A. There is a great need for interaction between colleges and industry in future in India as there has been interaction between the College of Advanced Technology and industry in the U.K. We too should re-orient all our Indian Engineering colleges somewhat on the pattern of CATEs in the U.K., for we should integrate, scientific knowledge with a purpose. If understanding is the fundamental goal of a scientist, utilisation is the final goal of engineers.

## ALLIED PROBLEM

## 1). Planning of Technical Man Power:

In every country, some sort of planning is done regarding the Technical Man Power. An Engineering Personnel Committee appointed by the planning commission in its report in May 1958, recommended the establishment of more engineering Colleges and Polytechnics, throughout the country. At the time of the outbreak of World War II in 1939, India had only eleven Engineering Colleges. Today, we have over 120 Engineering Colleges or Higher Institutions, with an annual admission capacity of over 20,000. That Committee made certain fore-casts, which, I regret to say, have not proved quite correct.

Even in the U.K., planning forecasts have been widely off the mark, e.g.

i) although the annual number of students qualifying in electrical engineering will rise by over 50% between 1960 and 1965, there will still be vacancies for about 4,000 in the later year (1965):

ii) notwithstanding the central position which mechanical engineering occupies within technology as a whole, the annual output of qualified mechanical engineers will have fallen by over 30% over the same period.

Every country is faced with such problems and is having some difficulty in resolving them!

ii) Supply and training of Technical Teachers

Every country is complaining of a grave shortage of technical teachers both in number and quality. In India, the average figure, as per Thacker's Committee Report is about 40% for engineering colleges on an All-India basis. There are some institutions in our country where this shortage is even 80% or more for atleast some months in the year, in branches like mechanical engineering and metallurgy. Even in the U.K. during 1955-56, the number of full-time staff in technical education was 11,500; the present estimate of requirements for 1965-70 is about 37,000, while number of places in the Technical Teacher Training Colleges is about 1,200. It is gratifying that about 100 of the Technical Teacher Training College students in the U.K. are from Commonwealth countries. Luckily, steps are being taken in several countries, including India, to have Technical Teacher Training in well established Engineering Colleges and also to establish separate Technical Teacher Training Institute, apart from the Refresher courses and summer schools, covering teaching methods. In my opinion, the training and adequate supply of technical teachers is the foundation on which all plans for the future development of

engineering education rest. This must be given the highest priority.

iii) Examination System:

An important aspect of Engineering Education is the examination system and methods used for the grading of candidates and evaluating their performance in theory, practical and oral. These systems vary very widely from country to country as regards question paper-setting and methods of valuation with internal and external examiners. In India, we have a system of sessional marks, which every engineering teacher considers as a necessary evil and very often the students feel that the teachers are abusing. If sessional marks are abolished, it would be difficult to motivate and measure the short-term progress of students. The evil effects of the abuse of sessional marks can be minimised, if they do not form more than 20 to 25 per cent of the total examination marks and there are both internal and external examiners for valuation of (1) Theory, (2) Practical and (3) viva-voce.

Here again, each country must evolve its own method, suited to its own sociological conditions. Neither the problem nor the solution with regard to examination system is as naive as is mentioned here. It is too involved to be elaborated in greater detail here.



**CONCLUSION:**

All over the world, there is a fear that in the foreseeable future, there may not be sufficient number of qualified technologists to meet our needs.

The function of all types of education, including engineering education, is to prepare a human being for life in a complex society. An institution meant to produce technologists must produce well-rounded persons able to appreciate their role in society. The rate of technology is so rapid that no technologist can hope to learn at the College all that he will need for say 30 to 40 years of his working span of life. He will be taught, like the scientist, how to learn and think for himself. A practising engineer must continually gather new knowledge or he will become a back number. It, therefore, becomes necessary for a practising engineer to spend continuously a part of his time in self-education, through refresher courses and reading new books and journals, if only to save himself from obsolence.

I may here quote from Maurice Goldsmith's booklet: "Careers in Technology".

"There is no major mystery in the immediate technological future. The machines that will be in use in a few years' time are on the drawing-boards, the new materials and processes that will serve us by the end of the

next decade are in the test-tubes, and the technologists who will shape the future in the 1980s are already out of their cradles. Although this is so, there remains a basic problem we are attempting to solve now: how to ensure that the next generation of technologists receives the kind of education that will fit them for our rapidly changing world".

"What is the direction we need to follow in considering the future education of a technologist? I cannot know the complete answer, for it will depend on the tasks he will be required to solve, and the nature of the scientific industrial machine that will be set up for him to work in. These things seem to me to be obvious; productivity of goods will increase (estimated by at least fifty percent by 1970 in the U.S.A. alone); hard physical labour by man will tend to disappear and routine mental tasks will be performed by machines. Our simple machine will be replaced by a new complex based on what we now call 'automation'. (There will not be any alternative to this development in the highly industrialised countries of the West as only about ten percent more human effort will be available to meet the increased demand for goods and services). The speed of this development will depend on the effectiveness with which newly discovered laws of nature are applied purposively to raise

productivity. The links between pure and applied research will become closer".

With this background against which we have to consider the trends in Engineering Education, I wish to conclude by saying that:

i) Plan we must, but it would be less than realistic to plan far too ahead in our fast changing nuclear and space age;

ii) While it is useful to draw from the experience of other countries, it is neither possible nor desirable to copy. We would do well to ensure that we do not repeat the mistakes of others;

iii) The nature of the problem being dynamic, its solution calls for open-mindedness more than anything else since there is no finality, much less sanctity about the ideas, plans, or schemes evolved. The means suggested to solve any problem at any time must depend upon the needs and resources available. This implies that the constraints and characteristics: technological, social, political, cultural, etc., which are even so peculiar to any country, have to be primarily taken into account.

## DISCUSSION:

R.P. ARTHUR wanted the syllabus to be made more flexible so that when new courses were offered, students would be able to go through it without much strain. The position of the teaching staff in the society should be improved not merely by raising the salary but by several other means so that the teaching profession will not be looked down.

According to him, one of the methods of improving this would be to place the teachers in firms at least for one day in a week. The necessary arrangements should be made by the administrative authorities in each institution. This association with industry will tend to benefit the students, the institution and improve the position of the teacher in society.

S. SANKARALINGAM asked whether it is advisable to continue increasing the strength in Engineering Colleges. He said that it is desirable to increase the mathematics and science content in the Engineering courses. But he wondered how many of the students admitted will be in a position to go through such a course. Since many of the students took up work in engineering industry or Government where much of mathematical or science knowledge was not required, he asked why should an Engineering student be burdened with such unwanted subjects. Regarding

teaching staff, there will always be a shortage. Since the creative urge is there in every individual, the teacher must be placed in industry where he can have responsibility and get the satisfaction of certain achievement.

V.V.L. RAO in his summing up, said that there was nothing wrong in our syllabus and that it was left to the teacher to lay emphasis on more important points. The course could be made more flexible, by teaching the basic subjects in the first two years and flexibility can be aimed at the higher levels. Regarding shortage of staff he felt that close co-operation with industry will be an advantage and that a close liaison between college and industry will improve the position of staff in colleges. This will also place the teachers in a better position in society. He suggested that top engineers from the industry could be appointed as visiting Professors in Colleges.

He said that spending a day in a week in industries is in vogue in England for quite some time, and that it should be tried out in India. He was certain that it will prove successful. In England, training in drawing and workshop technology is being reduced. But in our country however, they cannot reduce drawing courses at present. But some of the workshop training can be reduced and this training can be given at the high school level itself.

He said that to start an Engineering College, about 60 lakhs of rupees were needed for buildings alone. To obviate this, shift system was thought of at the initial stages. But the lack of staff for evening classes proved an insurmountable problem and hence they have to increase the strength in the Colleges.

He said that the trend all over the world was to increase the mathematic and science content in the courses. But a differentiation can be made between scientific technologists and engineering technologists. By suitable arrangement of the courses, such a differentiation can be done to cater to the needs of the country. He suggested the following books for the study of trends in the fields of technical education.

i) "South Kensington to Robins" 1851 - 1963 published by Orient Longmans.

ii) "Careers in Technology" by Monis

iii) "Trends in Engineering Education" by Brigadier Bose.

## TRENDS IN THE FIELD OF ENGINEERING EDUCATION

B. SENGUPTO

An extract of the speech is given below:

In the early period of technical education in India, the orientation was to provide training in building work, road work etc. to cater to the needs of the British and that this has been true in all countries and at all times. Depending upon the development of the country, the curriculum laid stress on certain aspects or objectives set for realisation in the country.

In this context, if they examined the trend in their technical education, the conclusion could be that the curriculum has not been set to be oriented towards the objectives. The fourth Five Year Plan has set certain targets for achievement. But it has not been clearly laid out, what type of personnel are required and on which aspect the stress should be laid. He was of the opinion that we are drifting from the requirements of our country as our objectives have not been fixed.

He said that Diploma and Degree curriculum have not been drawn and fixed properly. The degree curriculum without certain portions or chapters has become the Diploma syllabus. The technicians are not given the skilled training that they require or need and that the syllabi have not been oriented to what the student would do afterwards. He felt that their type of education must be

defined against their background, by Indian Engineers and Educationists to suit Indian conditions.

He suggested that if our education should be perfect they must decide their objectives, fix the number of personnel needed for various trades and give the type of training that the country needed of them.

#### DISCUSSION:

V.V.L. RAO said that each country must develop its own type of technical education. The trend in Western countries is towards more science orientation. In our country probably we can have two streams:

i) Science Oriented and (ii) Technology Oriented.

M.P. MATHEW said that they have degree, diploma and technician courses and besides that, they have the Junior Technical Schools and Government Technical Institutions. He wanted to know the place of the last cadre in Engineering practice.

N.M. JANARDHAN wanted that a diploma holder be given a chance to become a degree holder.

P. PURUSHOTHAMAN said that some one has pointed out that the Indian mind cannot move out of generality and come to a particular aspect. Thinking aloft, we have been planning on a wide scale, but falling short of achievement.



He wanted this trend to be altered.

K.S. HEGDE said that the point of view of SEN GUPTO was that Engineering Education is at a slightly lower cultural level. This was not true. Engineering uses the basic facts of science to man's benefit and engineering has cultural education built into it. He said that Engineering is universal and hence engineering education need not be based on Indian conditions. There is no harm in engineering education based on universal experiences.

S. NARAYANA BHAT wanted to know whether there can be a yard stick to divide the students between the various branches of Engineering. He felt that they must have a spiritual bias towards education.

LEO V. NOTHSTINE said that perfect conditions are not attainable. But according to him a goal can keep moving towards it.

In his summing up B. SEN GUPTO said that any education is not inferior to others. Mathematics gives education, but it does not give culture. When one appreciated the beauties of nature, one became cultured whatever profession he might belong to.

He said that it was not his aim to develop indigenous education. When they import foreign education they must adopt it with proper modifications. Education must be given by our people, to our people for our progress.

According to him a diploma holder may be given a chance to become degree holder. But, that should be only by proving himself as fit for the degree level - he should obtain the same proficiency in Mathematics and Physical Sciences as a degree holder. If the same salary conditions and social positions are promised to the diploma holder, the drift from diploma to degree level will disappear. If science oriented and technology oriented courses are started, the former would receive greater patronage, which must be avoided. He felt that if equality was guaranteed, the two stream proposition would work. If we knew our needs, our mind and our target, we could formulate a course or curriculum to suit our condition for a particular period of time. According to him Diploma education is the pivotal point of our industry and education given to them should be thought out well and in a planned manner.

## EVALUATION OF TEACHERS AND TEACHING

I.O. EBERT

Most teachers are dedicated people who sincerely have an interest in students and their progress. Because they love their work and the sparking of the interest and ambitions of their students there is often the feeling that actually this is not work, rather it might be classified as a paying hobby. Indeed, this view is often fostered by administrators and governing bodies who consider dedication as a part of the pay, so as to keep the actual monetary rewards considerably below that of industry.

On the other hand, it must be admitted that the teaching profession harbours a certain number of misfits who have chosen teaching as a haven from the rigorous of industry. Unfortunately these escapes from the cruel world are rarely fit to be teachers and do much to create a bad image of all teachers in the eyes of the public.

A system which gives increased rewards and promotions purely on the basis of seniority, without regard to performance, encourages the non-dedicated and discourages the competent teacher. So we have the question: How can good teaching be recognized and measured so that proportionate awards can be made?

In the final analysis, the measure of a teacher is the value to the student of the new information and insight actually conveyed and the degree to which the teacher has inspired the student to pursue knowledge and culture on his own. Unfortunately, neither of these factors can be readily measured. I suppose one approach to the measuring of information conveyed might be to weigh the teacher's lecture notes. If we could assume that every teacher's notes were written with the same degree of terseness and all were equal in the ability to transfer this information to the minds of the students this might have some validity - but immediately we can see the fallacy of such a scheme. The assumptions are clearly untenable; besides, quantity of material presented cannot be equated to the value of new information actually conveyed. Nothing is more boring than re-hashing of material already known, particularly if the so-called teacher presents it uninterestingly and does not propose new ways of viewing things. Thus we are left with no accurate way of assessing the value of the new material conveyed.

The second point made was that a measure of the value of a teacher is the degree to which he inspires the student to pursue knowledge and culture on his own. If measuring new information conveyed is difficult, measuring

inspiration is impossible. The fact is that the student himself may not even realize he is inspired. He may admire the teacher and want to emulate or perhaps to please him. He may 'hate' the teacher and work just to demonstrate that the teacher is wrong in his views of the student's stupidity or he may study to 'spite' the teacher and deny the teacher the pleasure of failing him. The student may be reacting to fear of an impending examination. Who will deny that these things are inspiration as is anything which encourages or forces the student to learn for himself? Very important in this category is the inspiration a teacher gives which will make a student curious so he continues to study beyond the bare essentials or continues an interest long after the final marks have been given. How do we measure such things as this? Certainly not by student evaluations of the teachers as proposed by some. While student evaluations have some validity and should be taken seriously, they usually average out to little more than a popularity contest. If a teacher is a 'good joe' and 'one of the boys'. If his lectures are not too demanding and if he gives good marks he is almost a sure winner in the student evaluation poll. As one great philosopher \* remarked recently "often a student doesn't realize until years later just how much

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\*Professor Leo Mothstine

he learned from some teacher who didn't particularly impress him at the time".

The evaluation of Colleagues is apt to be even less objective than that of the students. Colleagues rarely attend our classes (we probably wouldn't want them to). Except for those in the same speciality area, they don't even know what we are supposed to cover. None of them really know how effectively we do our job.

If colleagues, who at least have close contact with the students, are unable to judge our teaching accurately; how much more difficult it must be for a department head or other administrator who is normally aloof from the students and is often the same to much of his staff. For an administrator to judge the teacher by the few voluntary student reports he receives is unrealistic because rarely does a student seek out an administrator to commend the teacher. Usually only dissatisfaction will cause him to make the effort.

In these words I have sought to emphasize the inherent impossibility of measuring the real value of a teacher. Cannot we see then why administrators are so prone to seize on other bases for comparison of teachers? What is his most advanced degree? What research has he done? What papers has he written? Books? Speeches made? Professional Society work? Civic activities?

Summer work or consulting? Religions or political activities? What student activities does he supervise? What committees does he serve ? etc.

While such activities may have desirable effects on teaching often they have adverse effects. They do, however, have the attribute (from an administrator's point of view) that they can be readily measured: in quantity if not in quality.

As has been stated in previous sessions research by the teacher has the benefit of giving him close contact with the frontiers of knowledge - but does not guarantee that his teaching will be improved. In fact he often becomes so involved in this research that his teaching is neglected. Also, teachers whose duties include research are often given reduced teaching assignments to permit this research. How unrealistic it is to judge one whose duties are solely teaching on the basis of number of research papers written in competition with someone, whose duties include research. Also how improper it is to use the other non-teaching criteria enumerated as a basis for judging teaching!

The problems of evaluating teaching have been stated here and by the previous speakers. We have also put before you a number of reports and bulletins; two of the most significant of which are the publications of the

American Society of Engineering Education entitled 'Report of the Committee on Recognition and Incentives for Good Teaching' and 'Report on Evaluation of Engineering Education' - otherwise known as the Grinter Report. I commend both of these to you for your study.

Another aspect of this mornings topic is the evaluation of teaching. We often tend to equate this with the evaluation of the teacher but it is not the same. The teacher himself needs some method to evaluate his own teaching. We in the United States are able to do this quite effectively through proper use of the internal examination so that during the term we can determine the effectiveness of our teaching and modify our plans to correct deficiencies. I cannot emphasize too greatly the importance of an effective internal examination system to permit evaluation of teaching as well as attainment by the student.

Your comments and questions on this topic will be most welcome.

Thank you.



## EVALUATION OF TEACHER AND TEACHING

LEO V. NOHSTINE

An extract of the speech is given below:

It might be difficult to satisfy all students and at all times. A good teacher might be required by his students to take more subjects, more number of classes etc. From the point of view of colleagues, a teacher might be evaluated from: the number of papers published; whether he was energetic in his duties; whether he was generating new activity, whether he had contributed to the development of the institution, etc.

The three opinions that matter to a teacher are: opinion of the students; opinion of staff; opinion of administration. An evaluation form to obtain the students' opinion on such things as:

- i) from whom did they learn most
- ii) what changes would they like in the curriculum
- and iii) how could the institution serve the student community better?

## EVALUATION OF TEACHER AND TEACHING.

W.J. FLIEREISEN

An extract of the speech given below:

Every teacher must have an objective. He should develop a speciality in a particular field and become an expert in it. The teacher must have the capacity to draw the students to active participation in discussions.

He was of the opinion that any evaluation system was only a partial judgment. Any such system should consider: (1) the ability of the teacher to inspire the students, (2) the teaching aids used by the teacher - whether they were good. (3) whether he helped the institution in professional guidance, (4) whether he provided consultation service to firms and industries, (5) whether he took interest in community affairs and (6) whether he took interest in furthering his knowledge by registering for more courses in the early years and later by publishing research papers.

As the results of any evaluating system were quantitative, he suggested that it should be the Faculty who should run the universities and not the administrators.

## DISCUSSION:

S. SAMKARALINGAM said that teaching profession was a great challenge to the individual. The teacher should dedicate himself to the profession chosen and not aim at popularity by cheap means. A teacher should not be judged by the number of papers published by him. He warned that this might generate a tendency in him to slacken in teaching or neglect it altogether.

P. PURUSHOTHAMAN said that teachers have not been evaluated properly anywhere in the world. The control is in the teacher himself and it is important to evaluate oneself.

F.C. CHANDRASIKARAN wanted to know the role of the administrator in evaluating the teacher. He suggested that it should not be harsh and biased.

S. NARASIMHAN said that if there was less security, there will be the fear that one might get thrown out if he did not work well; it would develop an atmosphere for better work.

In his summing up LEO V. NOTHSTINE said that the curriculum, environment, subjects, laboratory systems, examination systems etc. contributed to make a teacher. If they were good, the teacher would improve. But he warned that if they were bad, even a good teacher might drop in proficiency.

V.V.L. RAO said that by way of evaluation it might be good to know what our students think of us.

## EXAMINATIONS AND INTERNAL ASSESSMENT OF STUDENTS IN ENGINEERING COLLEGES\*

T. MUTHIAN

The objectives of engineering education are:

- (i) A mastery of the relevant fundamental scientific principles.
- (ii) A knowledge of their limitations and their application in Engineering.
- (iii) A preparation for the performance of one or more of the functions of analysis, design, construction, operation and production.

The methods of instruction and training intended to achieve these goals should be so designed and devised as to draw out and develop to the maximum extent, the latent talent in each student. The demand on his time and faculties should be such as to stretch him to the utmost of his capabilities, so that his performance, both as a professional and as a citizen, would be at the highest level of his competence. The appropriateness and reliability of our examinations and tests depend upon how best they help to measure the achievement of these goals.

Engineering is far from static. It is a creative profession that is essentially dynamic and constantly advancing. Education for engineering is a process that must continue throughout one's career. One of the most

\*The paper was presented by Dr.V.C.Fulandaiswamy, since Sri T.Muthian was on a tour of U.S.A.

significant instructional goals in engineering education is to motivate and help the student to learn on his own.

Success in engineering, or for that matter in any profession, demands sustained, purposeful, systematic hard work. The ability to submit oneself to exacting mental effort over long hours can be acquired only through proper training and practice early in life.

Briefly stated, an engineering student should be helped to acquire, necessary knowledge of science and engineering, an enthusiasm for learning, the ability and the motivation for learning on his own, good characteristics of critical thought, and the capacity to apply knowledge to new situations. The usefulness of the instruction and training imparted must be judged against these criteria.

At present, the progress of the students in engineering colleges is assessed mainly through terminal examinations. Grades are awarded only on the basis of their performance in the University Examination. Sessional marks ranging from 10% to 30% for theory and/or practicals are allotted for certain subjects and they are added to the marks obtained by the candidate in the University Examinations.

Experience has shown that the poor standard and large number of failures in the annual examinations are

primarily due to the fact that the students do not work intensively throughout the year. Sufficient attention is not being paid to their day-to-day work. Their progress is not watched and evaluated regularly. Consequently, they undergo the course almost as a routine, postponing serious study and assimilation to the last few months preceding the University Examinations, and inevitably many of them fail. It is imperatively necessary to remedy this situation. Through a system of periodic testing and regular assignment of homework, the students should be made to develop the ability for self-study and the habit of systematic work.

A general procedure for measuring and progressively evaluating the student attainments is outlined below. It is aimed at:

- (i) Enabling the student to develop the ability for self-study and assimilation;
- (ii) Making the student work systematically and intensively throughout the year;
- (iii) Improving the standard and effectiveness of the instruction imparted.

#### EDUCATIONAL MEASUREMENT:

In any field of human endeavour, there is a need for evaluation, to assess the extent to which the objective

has been realised. In education, oral and written examinations and performance tests are employed as measuring aids. Almost any examination will measure something; but the examination must be so designed as to measure the qualities intended to be measured. A test that is expected to measure knowledge should not end in measuring the speed or writing. An examination intended to measure thinking ability must not turn out to be a measurement of memory. In short, a test must be appropriate for the purpose for which it is intended.

Another important characteristic of a test is its reliability. The final outcome of a test is a function of many variables. The individual characteristics of the student, the standard of his knowledge, and his ability to use it, are the only variables that should govern the result. But there are others like the examiner, the grader, the physical condition and mental state of the student at the time of the examination, the environment in which the examination is taken and the element of chance that favours some and hurts others. These extraneous elements cause fluctuations and reduce the reliability of the result. While it is not possible to eliminate the fluctuations completely, it is possible to minimise them.

The tests must be spread over the entire year and should be administered in all standard forms. It is accepted that an evaluation based on a number of measurements made during the course of the whole year is likely to be more dependable than the one based on one or a few tests. It must be borne in mind that every known form or procedure of measuring achievement, has some drawbacks or failings. Only by drawing upon a considerable variety of evidence can we be certain that our judgment is well-founded and fair to the student.

#### EXAMINATION - A MEASURING AND TEACHING AID:

An important fact, often not stressed, is that examination is not merely a measuring aid, but it is also a valuable teaching aid. Properly planned tests at suitable intervals would be very valuable both to the student and the instructor. In his book on 'Effective Teaching'. Fred. C. Morris lists out the benefits derived from the tests both by the students and the instructor as follows:  
"Value of tests to the students:

(i) Test scores when properly derived show the student what progress he is making in the course. He can compare his work with that of other students as well as his own previous work.

(ii) Tests identify the parts of the course which the student does not know well enough. Without tests,



students do not know where they are weak.

(iii) Tests cause the student to review work which helps him to organise and retain knowledge.

(iv) Tests give the student practice in the application of fundamental principles to varying problem situations.

(v) Tests when properly constructed, help the student to distinguish between the relevant and the irrelevant. Often, students spend as much time on minor details as they do on the more important ones.

(vi) Tests give the student a better conception of the objectives of the course.

(vii) Tests stimulate the lagging student to make a greater effort to learn.

Value of tests to the Instructor:

(i) Test scores show the instructor whether or not his presentation of the subject is sufficiently effective to accomplish the objectives of the course.

(ii) Test scores enable the instructor to compare the effectiveness of different teaching methods.

(iii) Test scores show the instructor which points he did not make clear, thus enabling him to go back and clarify these points.

(iv) Test scores enable the instructor to give personal attention and guidance to the students who

are experiencing difficulty with the subjects.

(v) Test scores may be used to help standardise instruction when there are several sections of the same subjects.

(vi) Test scores may be used as a measure of achievement.

A test is really an observation on the progress of both the student and the teacher as a team and provides useful information for the growth and development of both of them.

#### AREAS OF MEASUREMENT:

Engineering instruction consists broadly of the following:

- (a) Theory and problem solving
- (b) Design and Drawing
- (c) Laboratory and Workshop.

In each of these, a system of testing and measurement must be evolved so as to help the growth and development of the student in accordance with the objectives of engineering education and to assess reliably the progress he is making.

As regards frequency of tests, it may be stated that many short tests are better than a few long ones. In courses that need considerable amount of reading and preparation, one may take it for granted that the students

do not do the reading unless they are examined at frequent intervals. They tend to procrastinate and resort to last minute cramming. A considerable part of the year is spent without intensive working. As a general rule, tests should be conducted so as to ensure that the student preparation keeps pace with the progress of the course.

(a) Theory and Problem solving

The instruction in theory would involve, besides regular lectures, the following:

- i) Reading assignments
- ii) Problem assignments
- iii) Oral questions
- iv) Short quizzes (written)
- v) Hour examinations.

Each one of the above, if properly designed and used, is a very valuable teaching aid as well as a measuring aid. Details of testing, in part, would depend upon the methods of instruction.

For instruction to be effective, the instructor should prepare an outline of the course at least for a month in advance. It is desirable to give the outline for the whole year or at least for the quarter. The advance outline should consist of the material to be covered, and the order of presentation, references,

demonstrations and laboratory experiments connected with the topic, may also be indicated. It may be on the following lines:

Subject: Strength of Materials      Text: Den Hartog

Subject matter	Scope	Reading References In addition to prescribed Text	Wo. of Fe-ri-ods	Lab. Expe-ri-ment	Visual Aids and Demon-stration
Columns and Struts.	I. Buckling		2		
	a) Euler's column theory for long columns with hinged ends.				
	b) Other end conditions				
	Text: Chapter IX Arts: 36, 37				
	II. Eccentrically Loaded columns		1		
	a) Secant Formula				
	Text: Chapter IX Pages 192-194				
	III. Critical loads on short columns.	Timoshenko: Strength of Materials, Vol. II Chap. 5 Art. 34, 36	1		
IV Lattice Columns.		Timoshenko Strength of Materials Vol. II Chap. 5 Art. 34, 35	2		Movies on Col. Tests
	a) Effect of Shear on buckling strength				
	b) Buckling of latticed Struts.				

Dictation of notes should be avoided. For each course, a text book must be prescribed and it may be supplemented where necessary by reference to specific chapter or topics in other books or even articles in journals.

The students should be required to read in advance the portions to be covered in the next class or in the next two or three classes, as the case may be. Such self-study of the topics to be discussed must be tested by asking simple questions and awarding marks for the answers. Students may be picked up at random and a few may be covered in one class; during the course of the month, the entire class may be covered once or twice. The procedure adopted should be such that a student who has been tested once, does not feel that for some time he will not be asked questions again. He should be made to realise that unless he prepares in advance and is regular in his attendance, he is bound to lose marks.

Planned reading assignments must be given outside the prescribed text book. The students must be required to maintain library note books for each subject and the instructor should periodically collect and grade them. The development of the ability to 'dig and delve' for oneself and learn on his own, is even more important than the acquisition of purely a formal knowledge in a

certain area. Every effort must be made to achieve this goal.

After covering a particular topic in the lecture class, the Instructor might devote about 10 minutes for oral questions which will allow an opportunity for reviewing, and reflecting on, the portion taught and would be a test on the attentiveness of the class. After asking a question, the instructor may allow some time to set the entire class thinking; he may then pick up a student and ask him for an answer and award marks.

One of the alternatives to asking oral questions at the end of a topic, is distributing objective questions mimeographed in advance and asking the students to answer them. Good objective tests are very difficult to prepare, but when well designed, they provide a valuable means of assessing the general understanding by the class, of the subject matter covered. A brief period of about 10 minutes will be sufficient for such tests.

An one-hour written examination may be held once during the course of a month. Questions should be framed with emphasis on principles and to the exclusion of any undue demand on memory. It may be sufficient if the 'hour' examination is announced just in the previous class.

Home work problems should be regularly assigned. They should be illustrative of the current work with an occasional review problem to keep them in touch with earlier portions. Fewer assigned problems, but all of these more carefully prepared and corrected, result in better learning. Tutorial classes where the student is required to work the problems on his own or with the guidance of the Instructor, provide an excellent opportunity for gauging the students' learning. The problems assigned must be collected at the due time and valued.

In each subject, a terminal examination lasting for about two or three hours may be held at the end of each term. These examinations need not be held in an organised manner in the last week of the term as has been the custom at present.

The examination may be held by each staff member teaching the course some time during the end of the term. There will, on the whole, be three such examinations in each subject in a year and these three examinations together may account for about  $1/3$  of the total marks for the subject in internal evaluation. The terminal examinations should cover all portions taught during the respective terms. It is very important that tests and assignments be valued and returned promptly. It is a good practice to return them in the following class.

The students should not be made to wait for weeks to know their grades. Such delays defeat the very purpose for which the tests are conducted.

The student should not be made to spend more time on any subject than is justifiable considering its place and importance in the curriculum. He rightfully resents the instructor who demands more of his time than he should. In American Universities, a student is expected to spend at least one additional hour for every hour of lecture in the class.

At the end of the month, the Professor should process the marks awarded to the students in the tests and assignments during the month, reduce them to a base of 100 and post a list of marks and percentage of attendance in the first week of the following month. A register with proper columns must be opened for each subject and class, thus maintaining a detailed account of the student's performance and progress.

The monthly announcement of results of various tests and assignments will be a commentary on the performance of both the student and the Instructor. It would provide valuable material for self-analysis and present opportunities for improvement. The instructor will be more alive to the attainments of the class in so far as his subject is concerned.



(b) Design and Drawings:

Drawing assignments should be given to the students in advance and they must be expected to come prepared to the drawing class.

For each drawing, specific time should be assigned. At the end of each session, the plates must be collected and valued before being returned in the next class. At the end of the allotted time, the drawings should be collected and valued in whatever stage of completion they may be. The incomplete drawings must be returned and the students asked to complete them outside class hours and resubmit them before a specified date. Late completion and late submission may be penalised by appropriate reduction of marks. In general, work intended to be done during class hours must be completed in the time allotted for the exercise. Accuracy, neatness of presentation, appreciation for proportions and speed are the criteria for valuing the work.

Design exercises may involve both design and drawing or design only. As the student carries out the design, the Instructor may guide him along; but should not rush to help him out of a situation. By giving the student the result of thought in advance, he may deny him the process of thinking for himself. The design, when completed, should be collected, corrected and

valued before any drawing based on it is started. The corrections made, the improvements suggested and the changes required by the Instructor, should be incorporated in the design before the drawing is begun.

The procedure for completing the drawing based on the design is as has already been discussed.

(c) Laboratory Workshops:

Laboratory is the means of teaching the experimental method. It is also a place to learn the art of measuring the characteristics of natural phenomena and to develop appreciation for and understanding of accuracy and precision. It may also include analysis in which either a machine or an instrument is separated into parts to see how it works and what makes it work. In workshops, students learn certain techniques and understand things by actual doing (Practice).

The most important pre-requisite for effective use of the laboratory is the preparedness of the students for the work on the day. They should know and understand what they are doing, why they are doing and how to do it. This preparation may be made by a discussion in the previous class or in the lecture class and by distributing mimeographed instruction sheets and blue prints. Their preparedness must be tested by asking oral questions and grading them. Such a procedure would motivate the

students to ask questions about things they do not know or understand.

Each experiment and the corresponding report must be valued and graded as soon as the report is submitted. Submission of reports should be according to a fixed time schedule. Somewhere towards the end of the month, either a performance test or a test involving computations to obtain results from given experimental data or a written test involving basic information on instruments, measuring techniques etc., or any other test that is consistent with the main objective of the course, must be conducted.

As in the case of theory classes, the results of the grading in design, drawing, laboratory and workshop practice, must be reduced to a base of 100 for each month, and posted along with the percentage of attendance during the first week of the following month.

In this connection, an important point to be noted is that the institutional courses of study both on the theoretical and practical sides, are primarily intended to equip the students basically to take up a suitable professional career. The skill and proficiency in the particular job in which a candidate gets employed, have to be acquired by him necessarily through actual practical experience therein, as what he has gained during his institutional study i.e. in the laboratories

and workshops of the college, will only be practical knowledge through observation etc. of the working of machines and equipments, as distinguished from actual practical experience under factory (or production line) conditions, which teaching institutions cannot and need not provide. With the theoretical and practical knowledge gained by a student during his collegiate course of study, he becomes basically equipped to take up a technical job in the field of his study, and making use of that knowledge, he is in a position to gain the requisite skill and practical experience in the particular job. The position, therefore, is that a student acquires basic theoretical knowledge (in the lecture classes) and applied practical knowledge (in the workshop and laboratories) during his institutional study, and actual practical experience later when he is on a job which he has to do himself and in which he will acquire skill and proficiency only by long practice. This somewhat subtle distinction between practical 'Knowledge' and practical 'Experience' has to be noted and our institutional courses of study be organised and run accordingly, due emphasis being given to the practical knowledge to be acquired by the students.

#### AWARDING OF SESSIONAL MARKS AND MINIMUM REQUIREMENTS:

As already indicated above, it is necessary for a correct assessment of the work and progress of students, to test them on a day-to-day basis (through work assignments, and 'quiz') and also periodically (through written tests) in all the subjects (both theory and practical) and, therefore, a system of awarding sessional marks in all the subjects has to be followed. However, in awarding sessional marks, a uniform or common yardstick will have to be adopted by all the institutions, as there is no such uniform procedure now. For this purpose, the following may be adopted:

The highest marks to be awarded in each of the subjects except English, may be about 90% and about 60% for average work. For late submission of any work assignment, a deduction of 20% of the marks out of the total which might otherwise be awarded for the particular assignment (i.e. in the case of submission of the completed assignment within the time allotted), should be made.

In English, the maximum marks that may be awarded, should be about 75% only, and for average work, about 50%.

The staff members in direct charge of the day-to-day work of the students, should maintain correct and systematic registers showing the sessional marks awarded to each student. These registers and some of the

completed assignments and drawings should be scrutinised periodically, say once a month, by the Heads of Departments or Professors or Principals, and they should advise the staff member, concerned suitably, if it is observed, in any case, that the valuation is too liberal or too strict. A copy of the sessional mark list should also be put on the notice board of the Institution every month, so that the students may be aware of their performance and progress.

Excepting the sessional marks which form a very small percentage of the total, the present system of evaluation of the student's knowledge is based, as already stated, mainly on the University Examinations which are conducted at the end of the year. The shortcomings of such a system have already been discussed. However, academic traditions in our Educational Institutions are not yet established on sound lines and it may be necessary in the interest of maintenance of uniform standards that an examination system where question papers are set and answer books are valued by outsiders, may not be completely dispensed with. The need, therefore, is one of an effective combination of internal evaluation and university examination (i.e. external examination) and the aim should be to make the best of both. The striving for increasing the area, scope, and significance of internal evaluation

should be a continuous one and the ultimate objective is to make internal assessment the main criterion for promotion. This can be achieved only through a process of evolution. The pace of this evolution and the relative importance of the two methods of evaluation in the transition period, will naturally be subjected to much discussion, and any rigid formula during the transition period, is neither necessary nor possible. Once the principle is accepted, each university can implement the plan, as it deems fit, consistent with its concept of maintaining standards. A few suggestions are made in the following paragraphs to make internal evaluation effective and to achieve the main objectives outlined in the body of this paper:

In the past, the College of Engineering, Guindy, Madras, was awarding a Diploma of its own. Most of the students obtained both the Diploma awarded by the College and the Degree conferred by the University of Madras. Some were contented with the College Diploma itself. The Diploma was awarded on the basis of internal evaluation only. It seems desirable to revive this system, perhaps, with such modifications as may be needed.

For a pass in the College Diploma and for promotion to the next year of the course, a candidate should satisfy the following requirements:

i) In each subject, he should score an absolute minimum of 40%.

ii) If the marks by which he falls short of 50% in each subject is added up, it should not exceed 5% of the maximum aggregate marks for all the subjects.

Any student who fails to satisfy this requirement should repeat the course. Any student who satisfies this requirement may be promoted to the next year of the course. He may continue to be in the next higher class even if he happens to fail in the University Examination. He may take the university examinations later and pass them. The maximum number of attempts for the Degree may be as stipulated by the university concerned. At present, those students who are not eligible to go to the next year of the B. E. course, discontinue formal studies in the college for a year and this time is mostly wasted. In order to avoid too many students falling under this category, there is an implied need to resort to moderation and increasing percentage of passes.

In the proposal made above, these problems are mostly eliminated. Either a student repeats the course in any year or he is promoted to the next year of the course. Such of those students who are unable to satisfy the requirements of the university, but still secure the prescribed minimum in the internal evaluation in all subjects each year, may be awarded the



College Diploma at the end of the course. The level of the College Diploma may be recognised to be equal to the licentiate diploma awarded by the Technological Diploma Examination Board. The holders of the Diploma may, when employed, be started in the same scale as licentiate diploma holders, but with three advance increments to compensate for the three additional years spent by them. The College Diploma alone, will be of interest only to a few students, who, somehow find themselves unable to cross the barrier of University Examinations, but are still sincere and regular in their work and have acquired sufficient knowledge to practice the profession of engineering.

Coming to the University Degree, a pass in the degree course should be based both on internal evaluation and the external examinations( i.e. University Examinations). Equal importance may be given for both. It will also be desirable to make provision for compensating, to a limited extent, inadequate marks obtained in external examination by scoring high marks in internal evaluation and vice-versa. The requirements for a pass in the Degree examination may be as follows:

- i) A candidate should secure an absolute minimum of 40% in each subject in internal evaluation as well as in external examination.

ii) A candidate should secure 50% in each subject when the marks in internal evaluation and external examination are added.

iii) Either in internal evaluation or in external examination, if the marks by which he falls short of 50% in each subject are added up, the total should not exceed 5% of the maximum aggregate marks for each mode of evaluation.

It is clear from the above provision that in any individual subject, marks upto a maximum of 10% may be made good from one mode of evaluation to the other; but when all subjects are considered, such transfer should not exceed 5% of the aggregate in each mode of evaluation. It is also clear that a student who does not satisfy the requirement for promotion to the next class, will not be able to secure a pass in the degree course, however well he may do in the university examination. As such, those students who are not promoted to the next year of the course, will not be permitted to write the university examination for the corresponding year. In otherwords, a promotion to the next year of the course is a prerequisite for being able to sit for the corresponding year of the degree course. It may be desirable to illustrate the procedure by a simple example. Let there be six subjects for a course

and let the marks obtained by the candidate be as follows:

Subjects	Internal evaluation	External examination.
(1)	(2)	(3)
A	60	40
B	50	50
C	40	65
D	50	50
E	70	60
F	60	40

Considering internal evaluation, he has secured 50% or more in subjects A, B, D, E and F. Considering subject C, he has the absolute minimum of 40%, but needs 10% more to make it 50% which is needed for a pass. The necessary 40% marks are available for him from the external examination in that subject since he has scored 65%. The aggregate for the course is 600 and considering 5% of the aggregate, a maximum of 30 marks can be made good from one mode of evaluation to the other. As far as internal evaluation is concerned, he needs only 10 marks from the external examination, which he has. Considering external examination, he has secured the minimum for a pass in subjects B, C, D and E. In subjects A and F, he has the absolute minimum needed. For securing a pass, he needs 10% more in each of these two subjects and

they are available from the internal evaluation. The maximum marks that are made good come to 20 which is less than 50 that is permissible. So the candidate secures a pass.

The marks obtained in each mode of evaluation will remain as they are and they will not be altered. The mark sheet issued by the university should consist of both internal evaluation and external examination scores. The arrangement suggested above, has the advantage of being fair to all categories of students. There are some students who are regular, hard working, learn the subjects well, but are not quite good in scoring in formal examinations. There are others who may not be quite regular during the course of the year, but may have quick grasp, study the subject in the last few months, and do well in the final examinations. In the present proposal, some credit is given to each candidate to his area of strength.

In order to maintain uniformity in standards among candidates from a number of affiliated colleges, ranking and award of classes for the present, may be based on external examinations only, excluding the practical examination.

The proposal outlined in the foregoing paragraphs will lend itself to a gradual increase in importance of internal evaluation and corresponding reduction of the

importance of external examination.

All the students should be informed that they should secure not less than the minimum prescribed in sessional marks, failing which their progress will not be certified as satisfactory by the Principals and they will not be promoted to the next year of the (Diploma) class. They should also be informed that they have to put in a minimum attendance of 80% separately for:

- (a) Theory classes
- (b) Practical classes (Workshops and Laboratories)
- (c) Drawing classes

At the end of each quarter, a consolidated report of the monthly progress may be sent to the parent or guardian of the student.

In the case of a student who does not maintain the minimum requirement, a warning in writing must be issued by the Professor concerned, at the end of the first quarter, with a copy to his parent or guardian. If he fails to improve and make up, a second warning in writing must be issued by the Professor concerned at the end of the second quarter, with a copy to his parent or guardian.

The Head of the Faculty concerned with the subject or subjects in which a student is found to be not up to the standard, may consider the desirability of

calling the student concerned before him or before the Faculty Council and advising him suitably quite early in the year.

On the conclusion of the course, each student may be given a certificate by the College in a proforma similar to the one given in the Annexure. In column 9 the Professor may record his overall evaluation of the candidate and make mention of those aspects that have not been covered in the previous columns. If the student has been guilty of participation in any strike, or any unruly behaviour or indiscipline etc., specific mention should be made thereof.

In conclusion, it can be assumed that by adopting the procedure of evaluation outlined, the standard of student performance can certainly be improved and if the assessment and grading are properly done, every student who is sent up by the College for university examination can be expected to pass. The total number of students enrolled in each branch and subject of study, the number of students sent up for University examination and the number that come out successful, will, to a great extent, indicate the standard of instruction and the quality of evaluation and grading adopted in the internal assessment. A list giving the above informations shall

be forwarded to the Director of Technical Education by each College. The office of the Director of Technical Education will tabulate the results of all the colleges and use it as a basis for assessing the relative standing of the various institutions.

The procedure outlined above can be adopted with suitable modifications by Polytechnics and allied institutions under the Directorate of Technical Education.

The procedure of internal evaluation discussed above is only a broad outline. The members of the Faculty may work out the details for each subject.

#### ANNEXURE.

(Proforma for issue of certificate)

(Name of the College)

1. Name of student

2. Date of birth

3. Period of study

4. Field of study

5. Academic Performance

I B.E.	II B.E.	III B.E.	IV B.E.	Final B.E.
Subject Marks	Subject Marks	Subject Marks	Subject Marks	Subject Marks

6. Attendance

I B.E.	II B.E.	III B.E.	IV B.E.	Final B.E.
Percentage of attendance				

7. Extra curricular activities
8. Conduct and behaviour
  - a) towards staff members
  - b) towards fellow students
9. Special remarks (giving an overall grading using symbols 'A', 'B', 'C', 'D' and 'E' for this purpose - vide note below)

Signature of the Professor  
concerned.

Signature of the  
Principal

Note: A : 75% and above    B : 60% to 74%    C : 50% to 59%  
       D : 40% to 49%        E : Below 40%

#### DISCUSSION:

R. SAMUEL said that in the paper, mention was made of reading assignments. The practice prevailing is to deliver all the material in the class from what the teacher had assimilated. It would be good to make the students read for themselves and this needs prescribing a text book for each subject. For such of those who could not afford to buy text books, copies must be available in the library. To implement all that was said in the circular, more clerical and other types of staff would be needed. He thought that if they could switch over to the semester system, two semesters a year would be better.



Retention of the student for a longer time in the College would only tend to reduce his efficiency after a certain stage. If more time was allowed to him for self study and assimilation, the problem of shortage of staff could also be minimised and the efficiency of the students increased. He wanted a system of examination to be devised to avoid wastage.

M.P. MATHEW said that the system seemed extremely complicated. Indian Institute of Technology, Madras had only internal valuation. He wanted to know that if they could do it, why not that be followed in Guindy. Engineering Institutions could conduct their own examinations and evaluate the students. He urged that there must be a move from the Engineering Institutions in this direction.

N.M. JAYARAMAN said that it was wrong to state that 'Engineering was not static'. Everything was changing and so it was not correct to say engineering alone was not static. He wanted to know how much time should be spent in correction of tutorials and drawing work. A norm should be laid to indicate the amount of time one could spend on each type of work.

S. SUBRAMANIAN said that it is said in the paper that maximum awarded may be 90% and 80% etc. He wanted to know why should that not be 100%. He further asked why

should they stop at 90%. The grades of the students need not be published to humiliate those who didn't do well. A sliding system can be arranged to fix the minimum for a pass to take care of the stiffness of the paper set or any such vagaries.

S.T. NAGARAJA said that the suggestion made in the circular to give more importance to internal assessment was good. At present where one book cannot cater to the syllabus, more books are prescribed. To avoid this he wanted the books to be written to suit the syllabus. He felt that the proposition of awarding diploma based on internal assessment was a good one. Imposing only a class assessment in the laboratory work without an examination might not be good and the students would aim only at the minimum and neglect deeper study.

M.S. JEVADIVA said that the circular stated that a student should score 40% in each (class and examination) and 50% in aggregate in the six subjects listed. It was not clear whether, where there were more subjects and when a student failed to satisfy this rule, he should reappear for all the subjects. He thought that it was unfair and the regulations must be framed to enable the students to appear only for the failed subjects or a group of failed subjects. He wanted the external examination to be only

in specified portions with reference to text books. The grading into classes should cover the results of all four or five years of study.

P.L. MEIYAPPAN felt that an assessment of the student both by an external and an internal examiner as in Indian Institute of Technology would be better. If a student failed in one subject or so, a summer course or evening classes might be arranged to avoid his repeating the course.

H.S. SHIVASWAMY said that the scheme envisaged in the circular aimed at introducing greater stress on internal assessment by apportioning a large percentage of marks for class work. This would produce greater control over the students' day to day activities. He said that the question of educating a student was not only that of a teacher but also of the university. According to him 50% of the responsibility was theirs. It was for them to say whether a student was fit to pass or not and it was better to give the university its place.

W.J. FEIEREISEN said that it was good to give reading assignments, tutorial work etc. But it needed a lot of work on the part of the staff and many hours of work every day.

If all that was said in the circular could be done, it would be wonderful. There must be confidence on the

teaching staff and the institutions must depend only on internal examinations. External examinations were unnecessary. He suggested that if the various institutions could have their own examinations and award degrees to students, there would be greater incentive among the staff to boost the reputation of their Institution. But a certain standardisation was necessary among the institutions. He said that whether an institution could be accredited or not could be decided by a committee as the ECPD in U.S.A.

In replying to the discussion V.C. KULANDAISWAMY observed that one should differentiate between a new and young Institution like the Indian Institute of Technology, Madras and institutions like the College of Engineering, Guindy, and other colleges affiliated to an old and well established university like the University of Madras. Old institutions with their traditions have their own advantages as well as disadvantages. Major changes are difficult and they have to be gradual. In proposing changes in such a set-up, one should necessarily take into account what is realistic and practicable. It will serve no purpose drawing up an attractive scheme which may not be accepted by those who matter.

We are convinced that the present system of pure external examinations is not very satisfactory and it

must be changed. There are seven Engineering Colleges, affiliated to the University of Madras. Some of them are old institutions and there are others which are new. To declare all of them overnight as institutions having a University status, empowered to conduct examinations and to award degrees on their own is not at present realisable. They may in course of time attain such a status, but we are concerned with how best to achieve that and what to do in the intervening period. The transition from a system of complete, external evaluation to one of complete internal evaluation has to be gradual. You may make the change as quickly as possible; still you cannot make it abrupt.

The paper under discussion attempts to provide a method by which both internal evaluation and external examination will have more or less equal importance to start with and slowly the external examination will be eliminated, making room for complete internal evaluation.

Extreme measures for changes will be enthusiastically welcomed by some; and totally rejected by some others. We should not forget that the present system of examinations has its own band of ardent supporters and it is not as though there is unanimity about the need for giving up external examinations.

One may aim at what is ideal; but one should propose what is possible. The present paper contains suggestions that have possibility of implementation; and are bound to improve the performance of the candidates. I do not deny that the procedure in some respects is somewhat complex. We are not always fortunate enough to find simple solutions for complex problems.

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## CURRICULUM REVIEW : U.S.A. - INDIA

LEO V. NOTHSTINE

Leo V. Nothstine, Chairman of the session, referred to the topic, 'Curriculum Review: U.S.A and INDIA' and initiated the discussion by introducing a sample curriculum for a bachelor's degree in Civil Engineering in an American University (Table A). He stated that the curriculum should aim at development of leadership and should equip a man for creative thinking in any position in his professional field. Referring to the unbelievably large number of contact periods in Indian Universities (Tables B and C) he observed that the usage and familiarity with various tools and equipment in the normal course of life in America helped to reduce the contact periods in the class rooms and explained the pattern of examination adopted in his country. Three examinations are taken by the candidate since the beginning of the year, before he sits for his finals (Vide Table attached). If at the end of the first examination, the class average is high, the teacher would be encouraged to lead his class to higher realms; if the average happens to be low, he could consider giving more class assignments and perhaps devote additional time in touching on some topics again. This way, the teacher always has a feel of the class, knows the level of attainment and is in a position to make

adjustments by way of course alteration, if necessary, and is able to carry the class along with him. As to the importance attached to the examinations, suitable proportion of marks could be allotted to the sessional and final examinations and an ultimate gradation arrived at.

K. RAJARAMAN at this stage, stated that the system of examinations, such as the one, suggested by the Chairman, would work out all right only in the case of a residential university like Jadhavpur, Delhi, etc., but not in the case of universities like Madras, Kerala, etc. where several engineering colleges are attached to a single university and the system of judging a candidate by single examination at the end of the year prevails.

P. PURUSHOTHAMAN also, was of the opinion, that in the present system of examinations, the role of a staff member was merely to assist the university in classifying the students into various mark groups (60 - 70%, 70 - 80% etc.). The great drawback of the present system, he observed, was that it did not afford much of a scope to raise the standard of an average student.

The chairman suggested a decentralised control for the examinations, so that the college would have the final say in conducting the examination and grading the



students. A proper quality control, he felt, could be effected by a central committee appointed by the University and consisting of Professors and Professional Engineers to lay down the standards of evaluation.

K. RAJARAMAN was of the opinion that a properly organised system of internal assessment would be the only solution to the problem.

H. SHIVASWAMY concurred with K. Rajaraman and emphasized the role of sessional marks in maintaining proper standards. Complete independence in this connection, was sought by many members and there was some unanimity as to the vital role of internal assessment.

"Unless there was a necessity, the student normally abstained from the examination" - was the observation made by P. Purushothaman and this was termed a social problem by M.S. Jayadeva.

T.S. VENKATARAMAN<sup>W</sup> pointed out that an engineering graduate should be at least 50% productive when he comes out of the college and his studies must guarantee good opportunities after he finishes his course.

M. BAHAUDDIN emphasized that the integrity and zeal of the teacher is a vital factor in inducing the students to a high level of thinking.

TABLE - A

## Sample Civil Engineering Programme (E.E.)

<u>Fall (12 Wks.)</u>		<u>Winter (12 Wks.)</u>		<u>Spring (12 Wks)</u>	
FRESHMAN YEAR:					
Maths	4	Maths	4	Math	4
Com.skills	4	Com.skills	4	Com.skills	4
Chem. I	4	Chem. II	4	Engr.Com.	3
Nat.Sci.	4	Nat.Sci.	4	Nat.Sci.	4
Phys. Ed.	1	Phys.Ed.	1	Phys. Id.	1
SOPHOMORE YEAR:					
Maths	4	Maths	4	Maths	4
Social Sci.	3	Social Sci.	3	Social Sci.	3
Engr. Geology	3	Statics	5	Str.of Mat'ls	5
Surveying	5	Struct.Drawing	3	Surveying	4
JUNIOR YLAR:					
Humanities	4	Humanities	4	Humanities	4
Dynamics	3	Struct.Analysis	4	Indeter.	4
Thermo.	3	Hydraulics I	3	Struct HydraulicsII	3
Economics	4	Transportation	3	Soil Mechs.	3
Engr. Mat'ls	3	Physics II	4	Physics III	4
SENIOR YEAR:					
Steel Design	4	Concrete(R/C) Design	4	Sub.Struct.	4
Hydrology	3	Water Supply	4	Sewage	4
Law of Contr.	3	Construction	3	Estimating	3
Electives	( )	Electives	( )	Electives	( )

About 200 credits for degree - fixed by each University

1 credit = (1 hour in class + 2 hours individual study)

TABLE B - CONTACT HOURS REQUIRED  
B.E. DEGREE

	Ave. Entry Age	Course Length	Contact Hours
Univ. of Madras	16 $\frac{1}{2}$ Yrs.	5 Yrs.	6120
U.S.S.R.	18 $\frac{1}{2}$	5 $\frac{1}{2}$	5500
A.I.C.T.E.*	16 $\frac{1}{2}$	5	5400
Europe	19	4 $\frac{3}{4}$	4200
Australia	17 $\frac{1}{2}$	4 $\frac{1}{2}$	3900
U.S.A.	17 $\frac{1}{2}$	4 - 4 $\frac{1}{2}$	2500
U. K.	18 $\frac{1}{2}$	3 - 4	2100

\* All India Council on Technical Education.

TABLE C - INDIAN/AMERICAN COMPARISON

	Indian	American	Ratio I/A
Years of college	5	4	1.25
Days per year	200	150	1.33
Total Days	1000	600	1.62
Total contact hours	6120	2500	2.45
Hours-non technical	365	700	.52
Hours-technical	5765	1800	3.20
Lecture hours-tech.	3120	1100	2.83
Laboratory hours-tech.	2400	700	3.42

## "FORMAL AND INFORMAL LECTURES - PLANNING AND PRESENTATION"

H.S. SHIVASWAMY

It is now my pleasant task to introduce the topic "Formal and Informal Lectures - Planning and Presentation" for discussion by the participants assembled here.

As one who has been a teacher myself, I find a stage has been reached in the life of a teacher, wherein for his very survival, he has to be more critical of himself and device ways and means of constantly improving his standards of efficiency, if he is to invoke respect and confidence from the students. In my opinion, a teacher handling undergraduate classes in Engineering, suffers from the following limitations:

i) He has before him a set pattern of syllabus for each subject, which he has to fully cover during the year.

ii) He has to prepare the students for the university examination at the end of the year.

iii) He is also faced with the task of maintaining discipline in a class of unusually large numbers, very common in our Institutions.

With this background, I would now like to place before you some salient points in connection with the planning and preparation of lectures.

The programme of topics proposed to be covered in a month should be so drawn as to facilitate a continuous

building up of the subject.

Each topic must more or less lead and pave the way for the next topic to be presented. The order of presenting the topics is very important, as otherwise the student may fail to appreciate the entire subject as one continuous developing theme.

The topics should be covered at a more or less uniform rate, care being taken to avoid rushing through certain topics towards the end. It should be borne in mind that students require a certain time lag for the crystallisation of their thoughts.

The manner of presentation of a subject, itself a potentially significant factor, will depend very much on the nature of the subject - descriptive or mathematical. I would like to stress a few points for your consideration in this matter.

For descriptive subjects such as Materials and Construction, Highway Engineering, etc.

Neat sketches form the backbone of approach. It is regrettable that the student community takes this very lightly, and hence every attempt should be made by the teacher to make the students realise the significance of good sketches.

Sketches should be as few as possible and dimensioned so as to give an idea to the students about the

approximate dimensions involved in the actual structures in practice. This practice of supplementing a lecture with neat dimensioned sketches on the board or preferably by slides would encourage the students to develop the art of sketching, which I consider to be very important for an engineering student.

After the sketches are drawn, the teacher may explain, with reference to the sketches, the salient features of construction.

Where principles of design are involved, these should be clearly brought out by simple design problems. Let us now turn to the teaching of mathematical subjects.

All theoretical derivations should be shown clearly on the board. It is not uncommon to see that students attach more importance to the end results rather than the logic behind the steps and this tendency should be watched for and checked.

Typical problems in each chapter would have to be worked out. Here again, whether the teacher would work out the problems himself or would simply assign the problems to the students after completing the requisite theory would have to be thought over. Since the present pattern of examinations makes the student always examination-oriented, a teacher is often constrained to work out type questions from examination papers. How far this

would be possible, within the limited time available to a teacher, is a matter which has to be considered.

Regarding informal presentation of the matter, it should be possible for a teacher now and then to put some questions on the topic, to find out for himself whether the students have been able to follow him or not. It also enables him to suitably modify his lectures, thus ensuring that the entire class moves along with him.

Apart from all these techniques the fact remains that the success of a good teacher depends on the impression and confidence which he creates in the students and on his ability to present the subject matter in an impressive and intelligible manner to the students.

The foregoing points, I feel, would be helpful to retain the respectful role of the teacher, to which he is always entitled to, in Society.

#### DISCUSSION:

L.M. BAHAUDDIN observed that teachers, in their role of imparting knowledge, have a tremendous responsibility to ensure that their lectures are properly assimilated by the students. Formal lectures are the most dominant in India but informal lectures could be a very important and vital supplement. Citing the treatment of plastic analysis in a lecture class, he pointed out that many

students fail to visualise how the plastic hinges rotate. In such cases, informal lectures could be a valuable asset. In spite of the fact that the calibre of the students when they enter the portals of an engineering college is certainly not low, the large number of failures in the subsequent years of the course was distressing and this, he felt, was due to lack of informal lectures.

The speaker further observed that a time was bound to come when engineers would have to man the top managerial positions of important public projects. Informal lectures would help to create in young engineers self-reliance. He advocated strongly informal lectures.

V.C. KULANDAISWAMY observed that it was obvious that informal lectures have more importance. Still the reason for clinging to formal lectures even in advanced countries is probably the availability of only a few eminent professors, who have mastered the art of communication. He cited the example of Germany, where, in universities like the Technical University, Berlin, it is not uncommon to see 200 to 300 students in a single class room. The speaker further observed, that this leads to an interesting question: "What is the best way to plan and present a topic?" One way would be to proceed from simple specific cases, taking the simplest case and gradually introducing additional variables one by one, as the course



advances. Another way would be to take up a general case and after proper illustration of the general case, show how a particular example is only a part of the general expression. He cited in this connection, the derivation of Bernoulli's Equation - as just a part of Navier - Stokes' Equation of fluid flow.

LEO V. WOIWISTINE intervened to say that in the derivation of mathematical expressions, it was important that the physical significance of each term in an expression be clearly brought out to enable the student to have a clear mental picture of the whole process.

Y. ANANTANARAYANA was of the opinion that the method of planning and manner of presentation would depend on the nature of the topic covered and on the level of attainment of the students. Even in the case of post-graduate classes, he felt, the method of proceeding from simple cases to complex concepts would be more desirable.

C.T. SRIRAMULU generally concurred with the views expressed by H.S. Shivasamy.

J. DEVARAJAN felt that building up from simple concepts to more complex expressions should be the procedure adopted in undergraduate classes whereas in post-graduate classes, the reverse case, might evoke thinking and appreciation in the minds of the students.

M. WALLUSWAMY stressed the need for informal lectures and said that sketches must form an important portion of a lecture.

T. AZARIAH said that in subjects like applied mechanics, there was a strong temptation on the part of many teachers to just dictate the basic underlying assumptions without really taking any trouble to bring out their significance and limitations. An informal lecture in such cases, he felt, would be of great benefit.

T.S. VENKATARAMANAN pointed out that the difficulty of taking notes in a formal lecture and the usual lack of cogency that one observes in them was the prime reason for resorting to informal lectures. In his opinion, students of Pre-University class have easy recourse to a set of fixed text-books but an engineering student is guided by a syllabus and the difficulty of procuring good text books as well as lack of suitable guidance at home would amply justify informal discussions. He particularly felt that informal lectures would pay rich dividends in design and drawing classes.

P. PURUSHOTHAMAN agreed that dearth of text books suited to our conditions, poses a real problem. He felt that even in the case of subjects like mathematics, informal lectures would be beneficial provided these were efficiently organized.

## ROLE OF TUTORIALS IN CIVIL ENGINEERING INSTRUCTION

P.L. MEIYAPPAN

The speaker, introducing the topic, referred to the unwieldy strength of our classrooms and pointed out how this had resulted in the student community being handled as a category rather than an individual. A system of properly organised tutorial classes would be a valuable tool to the instructor in assessing the reactions of the individual student and it would be possible for him to make adjustments by way of course alteration, based on these reactions. After all the teacher himself needs some method to evaluate his own teaching and he could advantageously make use of the tutorial classes for the same.

R. BHIMASEN RAO reiterated his view that the system of tutorials should be such as to encourage students to ask a lot of questions. Their difficulties in solving problems should be overcome by a series of simple questions and answers and the practice of straightway leading the student to the method would foil the very purpose of tutorials.

Y. ANANTANARAYANA wanted to emphasize the relation among formal, informal and tutorial classes. In formal lectures, the reaction of students is not studied, whereas it is felt in an informal lecture. Tutorial class is

one where one could study the ability of a student to apply his powers of thinking and conducted in the proper way, it would benefit even students of above-average level.

S.T. NAGARAJA felt that the teacher in-charge of the subject should make it a point to go to tutorial classes.

P. PURUSHOTHAMAN was inclined to observe that the present day students wanted everything to be spoonfed and posed a question as to what a student is supposed to do by himself when everything is covered for him in formal, formal and tutorial classes. Could the tutorials be taken to mean that the other lecture classes are conducted in an inadequate and inefficient manner? Could it not be made optional?

S. SANKARALINGAM said the moment the tutorial classes were made optional, the possibility of even a single student attending them was remote.

P. PURUSHOTHAMAN replied, in that case, tutorial classes serve no purpose and should be scratched.

T.S. VENKATARAMANAN intervened to say that all possible attempts should be made to provide an atmosphere for the student to make him study; if, in spite of that, the student did not respond, then nobody could. But, why deny the students a chance of being helped?

## " OBJECTIVES OF LABORATORY WORK "

K.M. BAHAUDDIN

The importance of laboratory work, as a valuable adjunct to instruction in a class room cannot be over emphasized. A visualised interpretation or correlation of theory to what is actually happening in the member or structure would help the student to understand the subject better. After all, theoretical instruction is an attempt - very often mathematical to predict the behaviour of say, a material or a particular structure. Because of the many assumptions involved in the theoretical derivation, a verification of the theory by laboratory work becomes necessary.

Laboratory work can mainly be of three types:

- i) To understand the behaviour of a material under certain specific conditions.
- ii) To verify theoretical deductions
- iii) To conduct quality control and production line tests.

Most of our colleges concentrate on the first type. To some extent this may be justified. But we cannot ignore the second and third type of laboratory tests. In Soil Mechanics, for example, where we try to predict the behaviour of soils, the first type of experiment may be justifiable, but when we turn to the strength of

Materials Laboratory, I do not feel satisfied with the list of experiments specified for laboratory work.

I have very often put the question to myself - what is the purpose of conducting hardness and impact tests in the laboratory? I have not been able to find a satisfactory answer. We very often conduct tension tests as a routine affair. But I do not know whether this test is conducted as a preliminary introduction to plastic theory. It is not my intention to suggest that we should attempt to teach plastic theory. But what I mean is that the tests should be purposeful. A lot of instruction in theory of structures is being imparted and therefore experiments can be devised to illustrate many of its aspects. We can have simple experiments to prove say Reciprocal Theorem. Castigliano's Theorem, Influence lines etc. Such type of experiments will be probably more useful than the destruction tests.

Let us now turn to the quality control and production line tests. Quality control is a field, still in its infancy in India but is slowly gaining importance. I would not suggest that such experiments should be included in our curriculum but I feel that some at least of the existing tests could be interpreted that way. For instance, a hardness test is in reality, a quality control test. Looking from that point of view,

the carbon content of steel can be correlated to hardness number and therefore, the hardness number can be a measure of that particular constituent. In other words, the possibility exists, for the teacher to interpret some of the conventional tests in a way beneficial to the student.

There is yet another field where the laboratory plays a very important role. Model Analysis is now an important field in structural analysis; theoretically it is possible to solve any complicated problem by the brute force of numerical methods. But with an increase in the unknowns, the labour involved is so great that a truly mathematical method proves to be often formidable. In any case, circumstances very often force one to verify the correctness of it by a representative model.

I would now like to briefly summarise what I wished to say. We are applied scientists and the laboratory should, therefore, be fully utilised. The objective should be to get a visualised picture of the behaviour of the material or a member of a structure. The laboratory work should also be organised in such a way as to develop in the student a capacity to interpret and correlate facts. My experience is that the students are very good in conducting an experiment but are often unable to interpret a simple graph. If the actual graph deviates from the ideal one, an attempt is always

made to manipulate it to bring it in close conformity to the ideal graph rather than explaining the reason for deviation. I suggest that it is better to instruct the student regarding the details of equipment, procedure of the experiment, etc., and leave him to conduct the experiment, plot the graph if any and explain the graph. He should be left to explain the deviation and the reasons for them. This way, we would be able to guide him better to arrive at significant conclusions.



"PLANNING LABORATORY EXERCISES FOR A COURSE IN HYDRAULICS"  
S. NARAYANASWAMY

The main objectives in introducing laboratory courses in Hydraulics for a Civil Engineer may be stated as follows:

- i) To bring about a realisation that experiment and theory . . . an entity,
- ii) To bring about clearly the difference between the ideal approach and the actual system,
- iii) To inculcate in him the art of using the measuring devices,
- iv) To develop in him an experimental approach,
- v) To enable him to understand the fundamentals of the subject well
- vi) To inculcate in him the importance of laboratory work for conducting model studies, say in the design of hydraulic structures.

In the Five Year Integrated Course, a Civil Engineering student is imparted a laboratory course in Hydraulics in his third and fourth year. This practice is defective due to the following reasons:

- i) Much more time is spent on practical work than is warranted.
- ii) Candidates seem to do the laboratory work mechanically at a time when they are not mentally suited to receive the instruction.

iii) Laboratory work tends to become a set number of dull, routine and repetitive experiments which will curb one's enthusiasm for experimental work.

It is, therefore, necessary, in planning a proper programme for the Hydraulic Laboratory Instruction, to bear in mind the following:

i) Experiments should follow theory taught in formal lectures;

ii) Experiments should be such as to supplement the lecture class information;

iii) Experiments should have an orientation towards solving practical problems or be of use for design purposes;

iv) Experiments should be capable of stimulating the imagination of the student to the point of becoming research conscious;

v) Experiments should be designed in such a way as to encourage the recognition of common factors among a variety of ideas, recognition of similarities and the differences between unrelated facts or principles and these would assist in the development of organizational thinking on the part of the student.

It is preferable to place on the hands of the candidate beforehand a laboratory manual previously prepared so that the student comes prepared to the laboratory and

is able to proceed, straightaway with the experiment without much of instruction from the teacher concerned. It is desirable that the formal lectures and laboratory instruction are handled by the same staff member, thus enabling the latter to come into intimate contact with his students.

The laboratory instruction can be made more purposeful and less of a mechanical drill if it were possible to do away with the practical examination held by the University and substitute in its place a certain minimum sessional mark which may or may not be taken into consideration for purposes of classification.

Hydraulic laboratory programme can be better appreciated by a Civil Engineering student if in his final year he is asked to conduct atleast one model experiment to get the necessary hydraulic data for the design of a hydraulic structure in his assignment. Such a procedure will make the student fully conscious of the fact that his earlier laboratory training was given with a purpose. Such a training will also make him fit to take up research programmes later if he has a bent of mind in that direction.

Report writing is an equally important aspect of the practical work. Students should be encouraged to submit original reports and where feasible, these reports together with a test should form the basis for assessing his curricular work.

The active role a teacher has to play in putting through a laboratory programme to perfection cannot be over-emphasized. He should have his equipment working and programme ready; should be on the look out for improving the technique and quality of his instruction and should keep himself in touch with the latest advancement in his field.

## "PLANNING LABORATORY EXERCISES FOR A COURSE IN SURVEY"

D. JEEBALA RAO

Survey practicals in the under-graduate course differ from other practicals in one respect; in other practicals the object is to help the student understand the theory better by means of visual observations and quantitative measurements. In surveying, theory plays a relatively minor role, as a study of the theory is made to enable one to carry out the required measurements in the field whether they are linear or angular or both.

The planning of field exercises in Survey is done with the objective that a student, after the completion of his under-graduate course should be in a position to conduct the surveys required for various engineering works and to prepare the necessary plans and drawings. The mere know-how of surveying operations is not enough. He should have enough practice to carry out the work to the accuracy demanded for the occasion.

In all the universities in South India, this subject is covered during a period of three academic years (i.e. in the second, third and fourth year of the five-year integrated course). In the second year the student is introduced to chain, compass and plane-table surveying and levelling. This is followed in the third year by transit theodolite, tacheometry, curve ranging and triangulation. In his fourth year, the student is

further taught about Astronomy, Hydrographic Surveying and Photogrammetry.

At present, training in survey fieldwork is given in two stages. In the first stage, training is imparted in regular fieldwork classes with the sole object of making the student familiar with the various instruments used in survey fieldwork and with the principles of field operations. The second stage of training takes place in "Survey Camps" organised for a period of about three weeks, to enable the student to acquire enough skill to conduct the survey operations to the desired accuracy. Only during camp training, the student normally gets a chance to carry out field exercises in a type of terrain which he is likely to encounter in engineering works.

It may be generally accepted that compared to any other subject, better training is given in surveying in our curriculum. This is as it should be, as most of our students have to be still absorbed by the Public Works Department and Highways Departments, where they are required to carry out preliminary surveys for various kinds of projects.

In certain quarters, doubts have been raised as to the utility of training our students in astronomical surveying, photogrammetry etc. This is a debatable point.

As the Survey of India Department have their own intensive training programme on these subjects and are much better equipped to give the training in these subjects, our teaching these subjects in the colleges amounts to more or less duplication of the work. In the light of the above, will it not be more desirable to eliminate these portions from our syllabi and restrict our training programme to two years instead of three years, as is being done at present?

#### DISCUSSION:

H.S. SHIVASWAMY felt that it would be desirable to bifurcate the laboratories into Applied Mechanics Laboratory, Materials Testing Laboratory, Model Testing Laboratory, Cement and Concrete Laboratory, Hydraulic Laboratory, Soils Laboratory, Survey Laboratory etc. He was of the opinion that experiments must be so selected as to incorporate both qualitative and quantitative tests.

K.M. BAHAUDDIN observed that in subjects like Strength of Materials, theory of Structures etc. one is primarily interested in the behaviour of a material, the behaviour of a member or the behaviour of a structure. The course of laboratory instruction as practised in our several engineering colleges is primarily devoted to the study of the behaviour of a material.

T.S. VENKATARAMANAN intervened to remark that perhaps that is all that is required at the undergraduate level.

K.M. BAHAUDDIN said that it would not be correct in his opinion to give equal weightage to strength of materials laboratory and survey practicals. When the Survey of India Department had expert facilities for training, he could not understand the need for a very extensive laboratory course in surveying at under-graduate level. He agreed with D. JEEBALA RAO on the idea of reducing the duration of instruction in survey from three to two years. In a similar way, he felt that tests such as hardness and impact tests did not carry any significance and questioned their utility in under-graduate instruction.

P. PURUSHOTHAMAN was inclined to agree with K.M. Bahauddin and said that acceptance tests could very well be taken out of the under-graduate curriculum.

Disagreeing with the remarks of K.M. Bahauddin and P. Purushothaman, T.S. VENKATARAMANAN observed that it would not be proper to condemn tests like Hardness Tests etc., which were easy to perform and cost very little. Each experiment had its own value and after all the usefulness of the hardness test by way of its relation to ultimate strength could not be questioned. He suggested a limited number of simple experiments for under-graduate



students and felt that advanced experiments could be taken up at higher levels. Perhaps experiments on tension, compression, bending and torsion would be quite adequate at under-graduate level and for this reason deprecated the idea of paying too much of attention on the layout of laboratories. On the survey side, he was inclined to feel that survey camps were very beneficial to the students as they conditioned the students for the job they would be called upon to do later.

D. JEEBALA RAO said that whereas sometime ago, there were only two or three laboratories on the Civil Engineering side, the tremendous development of technology had made imperative the addition of fluid mechanics and soil mechanics laboratories etc. He felt that the curriculum should provide for an equitable and balanced representation of the laboratory course in the new branches.

T.C. GEORGE asked whether the curriculum, already crowded, would be able to accommodate all the laboratories in the time-table.

K.M. BAHAUDDIN said that perhaps what was covered in the laboratory class need not be gone through in lectures again.

"THE OBJECTIVES OF PROJECT METHOD AND ITS USE IN CIVIL  
ENGINEERING - INSTRUCTION WITH SPECIAL REFERENCE TO  
HYDRAULICS"

V.N. VAPPICHA

To give a precise definition of the term 'Project Work' would be exceedingly difficult. For our purpose, I believe, it would suffice if we define it as a method of tackling a problem which cannot be solved within a few hours and which may or may not involve practical observations, laboratory experiments and theoretical analysis. It may require the judicious use of various theoretical aspects studied during a course of formal lectures. Therefore, the project method gives the student an opportunity to look back, recapitulate and assimilate the topics covered so far. The actual working of a project by a student can bring out points missed by the instructor during his formal and informal lectures, but which are necessary for arriving at a proper solution.

A project work may often be a problem connected with practical life. It is advisable to select a project, which is closely related to the nearby locality. This helps the students to correlate the theory and practice. The consideration of the various factors as they exist in the locality would help the student in visualising more complex conditions, that may occur during the future career of a student.

A project may be worked out either by a single

candidate or by a team of three or four persons. Team work may facilitate to bring out various special features of the project, which may not be always apparent to a single candidate. The definite advantage of mutual and continued thinking and free discussion that accrues from team work cannot be ruled out.

In Hydraulics, various topics such as design of diversion works, investigation and design of a canal system, studies in river training, model studies of Hydraulic structures, problems in backwater computation etc. are topics which can be taught better by way of project method, rather than by formal instruction.

Let us consider the example of the design of a river diversion work. Before the design work can be taken up, one has to collect pertinent data such as the ayacut and duty, maximum flood discharge, levels and distances of ayacut, whether or not navigation facility is to be provided, the effect and desirability of reducing the waterway, the size and availability of crest shutters, the additional benefit of providing a roadway and the economy in selection of construction material etc. These data and other design considerations are bound to be different for different projects and they cannot obviously be discussed in detail in formal lectures. It may be possible to indicate only the general methods of approach

to such practical problems and the actual application of the methods and a capacity to take correct decisions based on data collected, are best learnt by the students in project work.

To sum up, it may not be an exaggeration to say that project method is a better method of instruction compared to the method of giving isolated and unrelated problems in lecture classes. It stimulates the habit of thinking, mutual co-operation and the capacity to face problems as they exist in nature. It also provides the student an opportunity to appreciate and understand practical adjustment to the theoretical approach to a problem. It helps to imbibe in him the quality of originality and resourcefulness and gives him a better knowledge of the application of theory to practice.

"THE OBJECTIVES OF PROJECT METHOD AND ITS USE IN CIVIL  
ENGINEERING INSTRUCTION WITH SPECIAL REFERENCE TO SOIL  
MECHANICS"

M. S. JAYADEVA

Application of Project method techniques, in my opinion, is sure to fetch benefits, particularly in a subject like Soil Mechanics. Let us consider for example the typical case of an earth dam design. The students shall be given the data regarding the site conditions and also samples of soil available at site. They should conduct tests on the soil samples to determine the various index properties and then proceed with the design aspects of the problem, such as fixing up the height of the dam, stability of the slopes, drawing the flow-net diagram and providing proper filters etc. In the course of their assignment, they should also collect the available literature dealing with the different stages of construction work. Finally they have to compile all their works and present it in the form of a report.

As the students have to do all the tests to know the various index properties of the available soil samples, a complete range of the varied nature of soils is now presented to them. The tests give them a picture of the characteristics of sandy, silty and clayey, soils. Rather than giving them a set of values for the various soils encountered, this procedure would enable them to have a feel for soils and imbibe more confidence in

dealing with actual soil formations in future. The significance of the various tests and the necessity for a judicious interpretation of the same is now brought to them in a greater emphasis. As they have to test the stability of slopes under different conditions it would give them a much clearer picture of which type of shear parameter they have to use under specific conditions. The slip circle analysis would give them sufficient design experience to select the most economical section of the dam. The collection of literature from various sources would give them ample idea of the various features of earth dams from reconnaissance to completion. When the necessary drawings, specifications, schedule of costs etc., have been prepared and the project report is completed, I am sure, that the students would certainly feel happy and proud about their work. The project work would have certainly given them a boost to their morale and makes them confident of entering the professional field.

In conclusion, I would like to state that the project work method enables the students (i) to have an appreciation for the laboratory testing works (ii) to develop confidence in the analysis and design of project work and (iii) to gain familiarity with the various execution aspects of the project work. As rightly pointed out by K. SATHIVAGAN in his talk on

"Development of Originality and Resourcefulness", the project work method provides considerable scope for the student to think and study for himself and to apply theoretical principles to practical problems in an intelligent manner. Even though project method has not yet found wide acceptance in our under-graduate curriculum on account of the large number of students to be handled and the vast syllabus, its introduction in more and more subjects should receive careful consideration.

"THE OBJECTIVES OF PROJECT METHOD AND ITS USE IN CIVIL  
ENGINEERING INSTRUCTION WITH SPECIAL REFERENCE TO SURVEY"

D.V. GANGADHAR

Project Method is a very effective and valuable method of making a student understand and appreciate the application of theoretical knowledge to practical problems. In this method, a student or a group of students is entrusted with a certain project and is asked to collect data, may be from the field, or from laboratory tests or from books depending upon the nature of the project, and it is the responsibility of the group to work out necessary design sheets, drawings etc. with the help of knowledge imparted to him in formal instruction.

The benefits derived from a properly conducted project work are manifold. In this method, a student has an opportunity to utilise the knowledge, which he has acquired to practical application in a better way. The practical feasibility of many of the theoretical concepts delivered to him in formal lectures, is clearly brought out. He gains measurable confidence in tackling field problems. It makes him better seasoned to take up a professional career.

Especially in a subject like Surveying, which is more practical in nature, the usefulness of the project method of instruction cannot be over emphasized. Owing



to lack of time, it is seldom possible to teach every student the practical use of the various surveying instruments.

On the other hand, if a survey camp could be arranged and a specific Project, like a Tank Project, Road Project or Restoration Project etc., is given, I am sure, the student would be able to utilise his knowledge better. He has ample time and guidance and becomes proficient in the handling of the equipments. He learns the subject better this way. This way, a formal instruction at any time cannot be considered equivalent to the project method of instruction.

I am happy to say that project method forms an important part of Civil Engineering instruction in Mysore State, in the Third, Fourth and Fifth year of the undergraduate courses. I believe, I can confidently say that students who have worked in a project survey are much better equipped to tackle practical problems when they become practising engineers and are more accustomed to the conditions and circumstances under which they may have to work as Engineers in investigation works.

May I conclude by saying that given the proper guidance, students would realise the importance and value of Project work as a very successful method of instruction, particularly in subjects like surveying.

## DISCUSSION:

S. SANKARALINGAM expressed perfect agreement with what was said in the papers presented, but complained that project work, of late, tended to become stereotyped and was incapable of truly measuring the originality of a candidate. This was particularly true when a single project work was planned for the entire class, resulting in an almost single solution, thus leaving no room for any original thinking on the part of the students. He suggested that students should be provided with only the very basic data necessary - as, for example, what could be expected to be supplied by a prospective client - and left to themselves to collect all necessary data, to decide upon a suitable structure, to properly analyse it and to prepare the necessary computation sheets, drawings and cost particulars. Introducing the project work, only at the final year level of civil engineering course, he felt, tended to deprive its full value to the students and he recommended its introduction from third year level, where, to start with, small projects like the construction of a residential building, a public library, a hospital etc., could be fruitfully allotted to the students. This would considerably help the students in getting a proper perception, with regard to form and size of a structure, aesthetics of design etc.

D. JEEBALA RAO, speaking next deprecated the idea of prescribing a single project work for the entire class of students. He recommended that a set of select problems covering six or seven different fields be placed before the students and they be asked to choose therefrom. This would evoke a spirit of enthusiasm on the part of the students and is bound to produce fruitful results.

H.S. SHIVASAMY said that prescribing project work in the field of Hydraulics did not appeal to him, as there was always a possibility that many Hydraulic Laboratories might not be properly equipped to deal with such special situations. He felt that the field of Surveying, Sanitary Engineering, Soil Mechanics and Structural Engineering offered more prospects for the successful inclusion of project work. Agreeing with the remarks expressed by S. Sankaralingam, he said, that only the minimum amount of data should be supplied to the students, so that their true potentialities could be measured.

C.T. SRIRAMULU was of the opinion that project works are best allotted to the students well before the examinations and suggested suitable incentives in the form of prizes and medals to bring forth the best by way of competition.

G. EKAMBARAN pleaded for the inclusion of sanitary engineering works under project work and deprecated the habit of prescribing always structural engineering topics for project work.

Alluding to the remarks made by H.S. Shivasamy regarding the impracticability of assigning project work in the field of hydraulic structures, K.R. BAHAUDDIN remarked that project works need not be necessarily on a big scale. He pointed out that an engineering student in his third year usually has a complete knowledge of design aspects of the various building component parts such as lintels, columns, beams etc. and this could be the right stage to introduce the project work to him. A simple building could be assigned to him at this stage and he be asked to particularly devote his attention to design features, form, disposition of members etc.

V.N. VAPPICHA remarked that team work in project work should be encouraged and to avoid repetitive designs, the number of students in each group could be restricted, depending on the nature of the work.

S. SANKARANARAYANAN disagreed with V. Vappicha and asserted that students should be given independent data and each one instructed to produce his own designs and drawings.

S.R. SRINIVASAN intervened to say that the staff position may not always justify such a course to be taken.

S. SANKARALINGAM replied that the fact that the basic data is the same does not necessarily mean that the ultimate design features should also be the same. The important point was to make the student think individually. All the different designs may not be economical to adopt, but, in his opinion, the question of relative cost should not enter at this stage.

LEO V. WOTHSTINE said that the project work should be regarded as a very valuable teaching and learning aid and conducted properly, would serve as a valuable tool for measuring the intrinsic values of the individuals.

R. BHIMSEN RAO, concluding said, that the utility of the project work could be considerably increased by permitting the staff members to be associated with construction firms and do consulting work. This way, there would be considerable scope for throwing a wide variety of practical problems to the students and to stimulate their thinking ability.

## "SEMINAR METHOD IN CIVIL ENGINEERING INSTRUCTION"

A. KULATHU IYER

Seminars in general involve the presentation of one or more topics of a particular subject by one or more individuals followed by group discussion.

In the class room type of seminar, a student selects a specific topic, which is generally allied to but not necessarily included in his regular curriculum or syllabus. He refers to a number of books and periodicals dealing with the topic chosen, makes a critical study and presents it in a clear and concise manner. The method, when faithfully implemented, has the specific advantage in that it brings the student in contact with a number of books and periodicals and makes him confident to transmit the information to others effectively.

It is not uncommon that most of our students generally feel reluctant or shy to put questions to the class teacher. A very common tendency is that they prefer to keep the doubts to themselves rather than getting them cleared. The state of affairs, I have observed, is slightly better when the topic is presented by a fellow-student. More constructive criticism is generally forthcoming and the student presenting the paper, equips himself better to answer the various questions.

Apart from this, seminars also provide an opportunity to improve a students' communication skills, or the ability to transmit information to others in an effective manner. The student finds himself in a better position to express his thoughts and face his audience confidently a distinct advantage for one who wishes to become a teacher, later in his life.

In most of our institutions, we have the seminar system in one form or other at undergraduate and post-graduate level. Civil Engineering association meetings provide opportunity to present papers on various topics. Individual evaluation of the efficiency of such meetings in seminars is bound to vary. I myself have not felt quite happy with the working of this system in our institutions. The response from the students is invariably poor. One of the reasons for this sorry state of affairs may be that participation in such seminars is at as yet compulsory and under the present system of examinations, a student does not feel any necessity to do so. The pattern of education still is that a student learns more by way of prescribed texts and dictated lectures; so much so, many a student find it difficult to search for outside references and to present a paper. This should change. A student should acquire the ability to know what to look for and where to look for,

in case he is faced with actual problems. In this respect, the seminar system, if faithfully implemented would go a long way in instilling confidence in the student, which would keep him in good stead.

#### DISCUSSION:

Expressing complete agreement with the speaker on the utility of the Seminar Method as a valuable tool in instruction, C. T. SRIRAMULU favoured the institution of prizes and suitable other incentives to enable students to more actively participate in seminars.

S. SANKARALINGAM wished to emphasize the role of the staff members in properly guiding the students to choose their topics. It was not uncommon to see students trying to bring in topics, far beyond their level of comprehension. He wished to stress the necessity of making all students actively participate in Seminar discussions, so as to derive maximum benefit from such a method of instruction.

Welcoming the seminar method of instruction Y. ANANTANARAYANA suggested that seminar method in conjunction with project method conjunction with project method could be tried out successfully.

H.S. SHIVASWAMY expressed doubts regarding the usefulness of seminars as a method of instruction.



T.S. VIKRANTARAJAN observed that if topics are properly chosen, the seminar method could be very effective in its purpose.

LEO V. NOTHSTINE, in his concluding remarks observed that the very inclusion of many other methods as tools of instruction as practised today would indicate that no one method would be satisfactory at all times and for all levels. Each method has to be tried on its own merits, he said.

## CURRICULUM PLANNING

K.M. BAHAUDDIN

Since independence, the syllabus for Engineering Education has undergone many changes. But the pattern of education has remained more or less the same. The course content alone in each subject has increased considerably and an average student finds it difficult to assimilate all that is being taught in the College. As a result some students find it impossible to get through. Others do selective study just to get through the examination. This results in wastage or improper utilisation of human talent. Planning a Curriculum should take into account national needs, the capabilities of the students and methods should be devised to utilise the aptitudes of the students with minimum wastage. There is a lot of difference between making syllabuses and planning Curriculum. As far as is known a rational study of the problems of Engineering Education has not been done.

Our students are having about 36 hours of class work per week. To assimilate one hour of lecture, an average student may require about two hours of home or library work. Laboratory work may not require so much time. On the above basis a student may have to work 12-15 hours a day to assimilate all that is taught in the class. This is a difficult task and if we try to force

upon the student this amount of work, the result will be wastage of time and energy on the part of students and staff. There will be complaints of falling standards and wastage of talents. A similar student in England or America has only about 24 hours of work per week.

In Indian Universities so many subjects are being taught to the students. For example a Civil Engineering student is trained to become a Structural or Building Engineer, Irrigation Engineer, Public Health Engineer, Transportation Engineer, etc. We will have to admit the fact that it is not possible to make him competent in all these fields. Actually the student will choose any one of this branch for his career. Therefore, it is unnecessary to train the student in all the different branches of Engineering.

In olden days we were training the students for a job and the opportunities were limited. We give him some information about everything so that wherever there is an opening he can get in. He need not be very competent because all the designs were coming from England. To-day we have to produce Engineers for national needs. So the Curriculum Planning must foresee the future needs of the country. The country is planning in terms of 5 years and the Engineering Education should consider the developments 10 years hence, since a student will take about

5 years to get an Engineering Degree. At the present trends in our five year plan the investment may be of the order of Rs.50,000 crores. Naturally the pattern of investment will be different and the young Engineers will be called upon to shoulder new responsibilities.

I am of opinion that, more than ninety per cent of students are sincere and hardworking. This may be true with the teachers also. But there is frustration everywhere. This is probably because of the fact that course content is so much that neither the student nor the teacher is able to do full justice to the subject. We will have to accept the fact that it is not possible to make a student competent in all branches of Civil, Mechanical or Electrical Engineering within 5 years of Engineering education. It is unnecessary also. The curriculum should be oriented for example to train not a Civil Engineer but more competent Irrigation, Public Health, Building Engineers etc. In other words, optional system is to be introduced.

The available time should be distributed according to the importance of the subject. When the map of the country was being prepared surveying had much importance. The same subject need not have the same importance today. A Highway Engineer or Public Health Engineer should know more about the particular field of study and probably

nothing or very little about ray Irrigation. In this way the available time can be utilised more usefully. This is not specialisation but accepting the fact that everything cannot be taught properly within the available time.

Majority of the students are absorbed in construction and their training need not have so much of Mathematics. The case is different for research worker.

The Curriculum should be laid out for the average student. In the final year there should be optional subjects so that even a below average student will be able to choose a group of subjects.

#### CONCLUSION:

To-day the course content is very heavy and an average student is not able to assimilate what is being taught. It is necessary to reduce the course content and this is possible only by giving optionals in the final year. Instead of giving a general Degree in Civil, Mechanical or Electrical Engineering. The Degree can in some branches of the broad category. Even if we accept such a Curriculum now, it may take 5 years for the students to be trained on the basis of the new curriculum. By that time the industrial development of the country will be sufficient to justify such branching and employment opportunities may be available in each branch.

## DISCUSSION:

N. VAPPICHA expressed his agreement with the views of the speaker and opined that specialisation in a particular field of Civil Engineering should be encouraged at Under-Graduate level itself.

H.S. SHIVASAMY was of the opinion that curriculum planning should be oriented to meet the requirements of the industry. He felt that a thorough study of the employment potentialities of our outgoing students was essential before a change in curriculum could be implemented.

It was the opinion of S. SAMKALINATHAN that the calibre of a student should be judged at the outset before a proper curriculum could be planned for him. He felt that the curriculum should be profession oriented. He advocated the inclusion of a course on teaching in the final year for such of those students who wished to take to teaching as a career.

LEC V. NOTESTINE, in his concluding remarks felt that a system should be devised by which a student's aptitude for the engineering course could be correctly measured in the earlier stages of the course itself, thus avoiding wastage. He suggested that the group prepare a model curriculum, and put it at the next session for comments.

## CAREERS IN CIVIL ENGINEERING TEACHING: OPPORTUNITIES AND LIMITATIONS

D. JEEBALA RAO

We in India are now going through a period of nation building activities. We have had so far three five year plans. If we take a look at our achievements so far, they appear to be quite meagre. We need many more five year plans to be on a par with the other well developed countries.

In this context, there is an ever increasing demand for the supply of technical personnel. This has resulted in an increase in the number of technical institutions and has made possible for an engineering graduate to take to teaching as a career worth pursuing unlike in pre-independence days when one took to teaching just for the love of it or just because he wished to have a relatively quiet life.

We have now in teaching profession opportunities for acquiring higher qualifications and to a limited extent research facilities too.

One who takes up teaching as a profession finds comparatively more opportunities for higher studies abroad - thanks to the generosity of such countries as U.S.A., U.K., Russia, France, Germany, etc. - apart from the degrees and the training one gets during his stay abroad, one finds that his stay abroad itself is a great

education in many respects.

A person who seeks great satisfaction and pleasure in the job finds it possible only in teaching profession. For a practising engineer, this may be almost unattainable.

In spite of all these opportunities we find that there is a great shortage of teachers. Obviously there are certain limitations.

In many colleges in South India, the salary scales of teachers is very low. Hence they are not attracting good talents for teaching. Andhra Pradesh and Madras have implemented the revised scales of pay, mostly based on the recommendations of All India Council of Technical Education. Some other states are yet to implement the same. Until such time the salaries are improved, we will continue to have shortage of teachers.

Another limitation may be due to the fact that the staff structure is not formed on a rational basis. In many instances it is rigid. On account of this some highly qualified and experienced teachers do not get promotions for want of vacancies, thus leading to frustration. Secondly there are far too many junior posts and only a few senior posts. Consequently the chances of promotion are quite bleak. It is suggested that we arrive at the staff required on the basis of a staff to student ratio of 1:10 and keep the ratio of



Professors, Assistant Professors and Lecturers in the ratio of 1:2:4. Provision should be made to keep the staff structure elastic and to create super-numerary posts as and when the situation demands.

At present the teaching profession has become a water-tight compartment, and there are no opportunities for the teaching profession to handle realistic problems. Hence the teaching profession is becoming rather highly academic and the practising engineers have no confidence in the technical competence of the teaching staff to handle realistic problems. In order to make the teaching profession attractive, there should be ample scope for consultation work.

Many of our colleges are administered like any other government departments. Consequently there is absolutely no academic freedom which is very essential for the teaching profession to thrive. On account of the age-old rules and regulations the teacher finds himself in a position in which it is difficult to procure the basic materials required for teaching such as chalk, duplicators, typewriters, etc. Scrapping of some of these cumbersome rules would go a long way in improving our teaching techniques.

There is yet another serious limitation, in the teaching profession. It is the usual practice that when

a young teacher starts his career, he is usually thrust with some subjects which all others feel reluctant to teach. No attempt is made to encourage the young teacher in the early stages of his teaching career. Consequently the junior posts in the teaching profession are taken up as a sort of spring board for jumping to a higher post elsewhere.

#### DISCUSSION:

LEO V. NOTHSTINE briefly preferred to careers in Civil Engineering Teaching as obtainable in U.S.A. and observed that quite a few years back, it was not uncommon to come across a Civil Engineering teacher handling a variety of subjects. Citing his own case as an example, he remarked that conditions in his country had changed however since then. The modern trend was for a civil engineering teacher to specialise in one particular field only and this, in his opinion, was a change for the better, in that it was more conducive for development of research.

S. SANKARALINGAM was however of the opinion that a civil engineering teacher should not confine himself to teaching a subject of his own specialization only. He was constrained to feel that this would not be practicable with the present shortage of teaching staff.

Agreeing with the observations of S. Sankaralingam, S.T. NAGARAJA said that to expect a teacher to confine his teaching only to his field of specialisation might result in an unbalanced workload, particularly in under-graduate classes. He felt that it should be possible to devise a system by which subjects could be changed by rotation among the staff, say once in three years. He stressed the role of refresher courses in enriching the knowledge of the teacher.

S.V. RAMASWAMY referred to the observations made by D. JEEBALA MAO with regard to allocation of all descriptive subjects to junior staff members and said that the situation was unfortunately true. He agreed with the speaker in his remarks that at present no attempt is made to encourage the young teacher in the early stages of his career.

S. SANKARALINGAM intervened to remark that just because a young staff member goes to a junior class, it does not mean that he is ranked inferior.

S. NARAYANASAMY felt that the allotment of lectures should be such as to ensure continuity throughout. Citing the provision of Hydraulics in third year and Hydraulic Machinery in fourth year, he said both the subjects should be preferably handled by one and the same person.

Expressing perfect agreement with the remarks of D. Jeebala Rao, namely, that the staff structure in many of the engineering colleges was very rigid, H.S.SHIVASAMY said that the adherence to a 'fixed number of posts' in an engineering institution interfered greatly with the career opportunities of a teacher. He favoured the adoption of a suitable system by which a teacher would be automatically elevated to the next higher grade, irrespective of the availability of posts or otherwise. In his opinion, it was necessary to bring about as early as possible an atmosphere, in which the teacher would have no fears about his future prospects. He wanted to know the conditions in U.S.A.

LEO V. NOTHSTINE said that in many of the American Universities a young teacher would be expected to get his Master's Degree within a period of three years after entering teaching line. In some cases, a period of five years was also allowed. He stressed the fact that the system in U.S.A. was more flexible and pointed out that the allocation of budget amount on a rational basis enabled the administration to pay the staff well commensurate with their qualifications.

C.T. SAIRAMULU disagreed with the remarks of D. Jeebala Rao who had observed earlier in his speech

that very often people preferred teaching, just so they could have an easy time. He further observed that lack of suitable incentives was the main reason for the present drift and lack of teaching staff in engineering institutions. He suggested the formulation of liberal leave rules by which teachers could visit other institutions, could work in engineering establishment or could devote that time towards working for Ph.D. Degree etc.

K.M. BAKAUDIN in his concluding remarks, observed that, in his opinion, that the problem of discontentment among engineering staff was only a reflection of the social problems facing our country. He wished to draw the attention of the members to the vital necessity of channelising the potentialities of the young people in a proper manner. The senior staff members could play an effective role in this. He cautioned against the maintenance of any system tending to destroy and jeopardise the talents of young, ambitious staff members. He favoured a thorough change in the present system.

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## PROCEEDINGS ON 21-6-1965

Prof. S. SRINIVASAN welcomed the participants. He outlined the general programme for the afternoon session and informed the participants that they are free to make any suggestion in the matter. He remarked that the group attending the session was a mixed one with a wide spectrum of interests. As such the subjects covered in the technical papers presented dealt with a wide field ranging from semi-conductor electronics to digital studies in power systems.

Prof. I.O. EBERT who spoke next briefly outlined the scope of his lectures on semi-conductor electronics. He emphasised that the usefulness and success of these lectures depended on the active co-operation of the participants.

The participants then introduced themselves to the group. At the end of the day the bio-data particulars of the various participants were collected.

## SEMI-CONDUCTOR ELECTRONICS

I.C. EBERT

The speaker introduced the subject and explained the underlying physical theory. Starting from the 'Bohr' model of the atom he proceeded to explain the various modes of excitation of the atom. This was followed by an introduction to the band theory to explain the action of semi-conductors. The concept of the electron-hole pair was then introduced leading on to N type and P type of materials. The action of the PN junction was explained by the use of energy level diagrams. It was shown how a PN junction may be used as a diode and as a voltage regulator. After defining the emitter collector and base as applied to an NPN junction the action of NPN type of transistor was discussed. The characteristic curves of transistors, the various equivalent circuits, etc. were then developed. The impedance, admittance and hybrid parameters were also derived. The speaker then proceeded to explain the different types of transistor amplifiers. Specifically the voltage and current amplification in a common emitter amplifier was discussed. The frequency cut off characteristics and the effect of saturation were examined in detail. With the help of slides it was shown how transistors are manufactured in industry. The speaker concluded his talk after indicating the versatile uses of transistors in modern technology.

ENGINEERING CURRICULUM AND COURSE WORK IN U.S.A. AND INDIA  
- A COMPARATIVE ASSESSMENT

Chairman, S. SRINIVASAN opened the topic for discussion with a few preliminary remarks.

M.H. JAMARDIAN wanted to know about the detailed curriculum and list of prescribed text books for undergraduate education in progressive institutions in U.S.A.

K. KAMARAJAN wanted clarification about the lecture/tutorial ratio and the tutorial work at U.S. Universities.

S. SRINIVASAN mentioned that in India it was common practice to have 3 hours of lecture work for the main subjects, supported by two to three hours of tutorial work per week.

I.O. EBERT stated that at Michigan State University, U.S.A., there was nothing like the tutorial system that existed in this country. The doubts of the students were cleared either during lecture hour or at the end of the period. The exchange of ideas between the teacher and the taught thus served the same purpose as tutorial system in India. Further the students were made to do a lot of home assignments which were subsequently corrected and returned to the students. Regarding the curriculum, the speaker said that during the first two years an under-graduate student studied a lot of Mathematics, Physics and Chemistry. The next two years were spent



Besides these, sometimes students submitted term papers on specific topic suggested by the Instructor.

Replying to a question of K. VENKATA SUBRAMANIAM regarding the exchange of Physicists and Engineers the speaker agreed that such an exchange will be beneficial to both. On a point raised by P.M. RAMANATHAN, the speaker gave the figure of staff contact hours as 12 to 15 per week.

At the request of M. ARUMUGHAN and S. NARAYANA IYER the speaker gave a brief account of audio-visual aids used for teaching.

T.B. PRATHASARATHI invited a discussion about laboratory experiments.

S. SUNDARAJAN initiated the discussion. He dwelt at length on the position obtained in India with regard to laboratory work and techniques. He was of the opinion that any scheme of practical work has to be drawn bearing in mind such factors like strength of class, aptitude of students, amount of experience of staff members and the desirability or otherwise of using laboratory manuals. The experiments designed should be of such a nature as to supplement the work done by the sketches in the class room. To this extent laboratory work has to be carefully planned.

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S. NARAYANA IYER and T.B. PARTHASARATHY dwelt with the number of hours of practical work and also the stress on accuracy.

S. RAMA GOVDA narrated his experience in conducting 3 hours of instruction class in one week followed by 3 hours of experimental work the next week.

ABNUL KHADIR wanted more stress to be given to project work in undergraduate curriculum.

I.O. EBERT wound up the discussion and remarked that there are still many U.S. Institutions having programmes similar to what is followed in India.

# SYSTEM STABILITY IN THE SENSE OF LYAPUNOV

P.C. CHANDRASEKHARAN

## INTRODUCTION;

It was in the year 1892 that A.M. Lyapunov published his now famous memoir about the stability of dynamic systems in a Russian journal. For over half a century his methods and concepts were understood and appreciated only by a few mathematicians. After the Second World War, the Russians began increasingly using the Lyapunov method for design purposes until it became one of the principal tools in the analysis of stability problems of the most varied type. During the past few years, Lyapunov's so called "Second Method" has been the subject of considerable research in the United States as well as in the rest of the Western World.

The objective of the "Second Method" or the direct method as it is called is to determine the stability of a system from the characteristics of a scalar function (called the Lyapunov function) associated with the state model representation of the system. The important point is that a knowledge of the actual solution of the system is not required to apply this method. This is in marked contrast to Lyapunov's first method, which requires the solution of the relevant set of differential equations in explicit form. To call Lyapunov's concept a method

is a misnomer. It is actually a philosophy of approach, a point of view which has had far reaching repercussions in the synthesis and design of nonlinear systems. Being a relatively new approach, Lyapunov's method holds out much promise for further development.

The direct method of Lyapunov is linked closely with our intuitive concept of stability. We understand a system to be stable if the system on being perturbed from its equilibrium state always returns to its equilibrium state or within some finite region of the state. Lyapunov has clothed this idea in proper mathematical form in the two definitions of his on stability given below

DEFINITION - 1: (Stability): An equilibrium state  $X_e$  of a free dynamic system is said to be stable in the sense of Lyapunov if given  $\epsilon > 0$  there exists a  $\delta(t, t_0) > 0$  such that if  $\|X_0 - X_e\| \leq \delta$  then  $\|X(t) - X_e\| \leq \epsilon$  for all  $t \geq t_0$ .

Here  $X_0$  refers to the initial state vector.

DEFINITION - 2 (Asymptotic Stability): An equilibrium state  $X_e$  of a free dynamic system is asymptotically stable if (1) it is stable (2) every motion starting sufficiently near  $X_e$  converges to  $X_e$  as  $t \rightarrow \infty$  i.e. for every real number  $\mu$  no matter how small, there exists a real number  $T(\mu)$  such that for some  $\delta$

$$\|X(t) - X_e\| < \mu \text{ for all } t \geq (t_0 + T)$$

# LYAPUNOV'S DIRECT METHOD.

The Lyapunov direct method reduces to the construction of a function  $V$  of the state vector  $Y$  viz.  $V(Y)$  whose total derivatives with respect to time has certain properties which assure stability. The method is embodied in two theorems proposed by Lyapunov given below without proof.

THEOREM 1 : A disturbed motion is stable if the differential equations are such that it is possible to find a sign definite function  $V(Y)$  having a time derivative which by virtue of these equations is sign invariant and of opposite sign to that of  $V$  or vanishes identically.

THEOREM 2 : If the differential equations of a disturbed system are such that it is possible to find a sign definite function  $V(X)$  whose time derivative would by virtue of these equations be a sign definite function of sign opposite to  $V$  then the disturbed motion is asymptotically stable.

EXAMPLE: It will be useful at this state to consider an example of a nonlinear system and the corresponding Lyapunov function.

Consider a system whose state model is

$$\frac{d}{dt} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 & x_1(t) \\ -1 & 0 & x_2(t) \end{bmatrix} - a \begin{bmatrix} x_1(t) & x_1(t) \\ x_2(t) & x_2(t) \end{bmatrix} \begin{bmatrix} x_1^2(t) \\ x_2^2(t) \end{bmatrix} \quad 1$$

where  $a$  is a constant greater than zero.

If we consider a possible Lyapunov function

$V(x) = x_1^2(t) + x_2^2(t)$  then  $V(x)$  is positive definite for all  $x \neq 0$

Then  $\frac{d}{dt} V(x) = 2 x_1(t) \frac{d}{dt} x_1(t) + 2 x_2(t) \frac{d}{dt} x_2(t)$

on substituting for  $\frac{d}{dt} x_1(t)$  and  $\frac{d}{dt} x_2(t)$  from the original equation 1 and simplifying we get,

$$\frac{d V(x)}{dt} = - 2 a \left[ x_1^2(t) + x_2^2(t) \right]$$

It is clear that  $\frac{dV(x)}{dt}$  is negative definite.

Hence all the conditions stipulated in Theorem 2 of Lyapunov are satisfied.

Therefore, the system characterised by Eqn. 1 is stable about the equilibrium point  $x_e = 0$ .

#### EXISTENCE OF LYAPUNOV FUNCTION:

In general there is no explicit technique for generating a Lyapunov function satisfying the required stability conditions. While the second method of Lyapunov sets forth the conditions that must be satisfied by these functions, there is no straight forward method in general for finding these functions.

#### LINEAR SYSTEMS:

There is an explicit method for generating Lyapunov function in the case of linear time invariant systems.

Consider the linear system equation

$$\frac{dX}{dt} = AX$$

Suppose we select a positive definite form

$$V(X) = X_t^T P X \text{ as a Lyapunov function}$$

$$\text{then } \frac{dV}{dt} = X_t^T P \frac{dX}{dt} + \frac{dX_t}{dt} P X$$

Substituting for  $\frac{dX}{dt}$  we have

$$\frac{dV}{dt} = X_t^T \left[ P A + A_t^T P \right] X$$

$P A + A_t^T P$  will be negative definite as required by Lyapunov's theorem only if

$$\left[ P A + A_t^T P \right] = - Q$$

where  $Q$  is some positive definite symmetric matrix

In actual practice  $Q$  may be assumed to take a simple form e.g. a unit matrix. We then solve the  $n(n+1)/2$  unknowns belonging to the symmetric matrix  $P$  in terms of system parameters, to assure stability for the system.

#### NONLINEAR SYSTEM:

In the case of nonlinear systems formulation of Lyapunov function is largely a method of trial and error. Letov<sup>2</sup> and Lure<sup>3</sup> have shown that for certain special class of nonlinear systems the system equations can be put in the canonical form for which suitable Lyapunov functions are known. The nearest direct approach that



we can make towards generating a Lyapunov function for a nonlinear system is by the application of Krasovskii's theorem. There is also a conjecture of Aizerman's which says that for a nonlinear system  $\dot{X} = AX + f(X)$  if a matrix  $K$  can be found such that

$f(X) \preceq K X$  then the system is asymptotically stable.

The direct method of Lyapunov is a very powerful one. It appeals directly to the geometric intuition of the system analyst; it refutes the time honoured statement that nonlinear systems are not amenable to analytical treatment. As has already been proved no general or particular solutions of the system equations are necessary in this method. The role of the direct method of Lyapunov in the rigorous synthesis and optimisation of systems is particularly noteworthy. A systematic technique for arriving at Lyapunov functions is one of the primary areas in which research work is going on at present.

#### GUIDE TO LITERATURE:

A very comprehensive paper on Lyapunov's second method by Kalman and Betram<sup>1</sup> appears in the ASME journal 1960. This article also gives an extensive bibliography on the subject. Detailed applications of the method are available in various articles scattered in Russian

literature. The books published by Letov<sup>2</sup>, Lure<sup>3</sup> and Malkin<sup>4</sup> are of particular interest. Bellman<sup>5</sup> and Lefschetz<sup>6</sup> both from USA have made significant contributions to the growing literature on this subject.

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- i) R.E. Kalman and J.E. Betram, - Control System Analysis and Design via the Second Method of Lyapunov Parts I & II, Basic Engg. Trans. ASME, June 1960.
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## APPENDIX

A SYSTEM may be defined as a collection of interacting objects with certain measurable attributes.

By a measurable attribute, we mean such of those characteristics of the system which are expressible in terms of real or complex numbers, e.g. Voltage, Impedance, Velocity, Mass, etc.

The characteristics of a system are in general governed by a set of equations. They may be algebraic, ordinary differential or partial differential equations.

One of the ways of describing a system is in terms of a set of independent variables known as STATE VARIABLES.

To apply the Lyapunov method it is necessary to describe dynamic systems from the state point of view. The state variables may be thought of as a set of information required about the past history of a dynamic system in order to predict its future evolution.

Extending our concept of vectors in three-dimensional space, we can conceive of a system described by 'n' state variables. The set of 'n' variables constitute what is known as a STATE VECTOR,

$$X = (x_1 \ x_2 \ \dots \ x_n)_{\text{transpose}}$$

The space occupied by a state vector in 'n' dimensional space is called STATE SPACE. The tip of the state vector, describes a curve or trajectory in state space as the system undergoes dynamic changes.

The 'norm' of an 'n' dimensional vector  $x$  denoted by the symbol  $\|X\|$  is defined as follows:

$$\|X\| = \sqrt[n]{\sum_{i=1}^n (x_i)^2}$$

A QUADRATIC FORM in variables  $(x_1 x_2 \dots x_n)$  is an expression in which each term contains the square of a variable or the product of two variables. The quadratic form  $Q(X)$  may be conveniently expressed in matrix form as follows:

$$Q(X) = X_t A X$$

where  $X$  is a column vector and  $A$  is a square matrix associated with the quadratic form

EXAMPLE : If  $Q(X) = a x_1^2 + 2 b x_1 x_2 + c x_2^2$

then the matrix  $A$  associated with  $Q(X)$  is seen to be

$$A = \begin{bmatrix} a & b \\ b & c \end{bmatrix}$$

A quadratic form  $Q(X) = X_t A X$  is said to be positive definite (negative definite) if  $Q(X)$  remains positive (negative) for all  $\|X\| > 0$

$Q(X)$  is said to be positive semi-definite (negative semi-definite) if  $Q(X)$  remains non negative (non-positive) for all  $\|X\| > 0$ .

Positive/negative definite forms are also called sign definite form in literature.

Similarly positive/negative semi-definite forms are also known as sign invariant forms.

The EIGEN VALUES of a square matrix 'A' associated with a quadratic form places the positive definiteness or otherwise of the quadratic form in evidence (Eigen Values are the roots of the determinantal equation  $|A - \lambda I| = 0$  where  $\lambda$  is the eigen value and I is the unit matrix). The following criteria are useful in this connection.

i) If all the eigen values of a symmetric matrix are positive (negative) then the matrix is positive (negative) definite.

ii) If at least one of the eigen values are zero and the remaining ones are positive (negative) then the matrix is positive (negative) semi-definite.

Alternately we can prove that a matrix A is positive (negative) definite if and only if the principal minors of A are positive (negative).

In the analysis of systems, we deal generally with non-linear vector differential equations of the form

$$\frac{dX}{dt} = f(X, u(t), t)$$

This form of equations is also known as the STATE MODEL form for the system. In the above equation X denotes the State Vector in 'n' variables u(t) is the control function or forcing function or input.

Vector Equation (1) is equivalent to a set of 'n' scalar differential equations

$$\frac{dx_i}{dt} = f_i(x_1, x_2, \dots, x_n, u_1(t), \dots, u_r(t), t)$$

$$i = (1, 2, \dots, n)$$

Linear systems are governed by the vector differential equation of the following form:

$$\frac{dX}{dt} = A(t)X + B(t)u(t) \quad 2$$

Here A and B are time variant matrices.

If Eq. 2 is further simplified we arrive at the time invariant linear system

$$\frac{dX}{dt} = A X + B u(t)$$

where A and B are constant matrices.

An example of such a system is an ordinary LRC network with arbitrary driving functions.

If the excitation function  $u(t)$  in the state model of a system is identically zero for all  $t > 0$  then the system is said to be free or unforced.

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## PRINCIPLES AND APPLICATIONS OF LINEAR MOTOR

K.M.A. Md. SULAIMAN

The speaker started with explaining the principle of operation of Linear Motor based on the rotating magnetic fields. He mentioned several applications of the motor in industry some of which are given below:

- i) Weaving Loom
- ii) Winding Packages of Yarn
- iii) Pumping Devices
- iv) Shaping Machines
- v) Take off of an Aeroplane
- vi) Drawing of Steel Wires.

He proceeded to explain the construction of the single phase vertical oscillatory motor with gravity used as a disturbing force.

S. NARAYANA IYER wanted to know about the frequency of oscillation of such a device. The speaker replied that it depends on the weight of the coil and strength of the magnetic field and that it does not depend on the frequency of supply.

S. NARAYANA BHAT wanted to know about the speed control and cost of the device.

The speaker replied that the speed comes down with load and magnetic field and that it can be controlled by controlling the current. Regarding the cost, it works

out cheaper than the conventional induction motor with the same rating.

ABDUL KHADIR and V. KRISHNAMOORTHY spoke about the purpose and rating of a condenser to be used in conjunction with a linear motor. K. ARUMUGAM gave an account of oscillations due to q-lag effect and ferro resonance jumps.

I.O. EBERT spoke about the use of linear motor in projectiles. P.M. RAMANATHAN, N.M. JANARDHAN and K. KAMARAJAN spoke about the design aspects of linear motor.



# AN INTRODUCTION TO THE PRINCIPLES AND APPLICATIONS OF SUPER CONDUCTIVITY

K. VENKATASUBRAMANYAM

The history of the discovery of super conductivity dates back to 1911, when Kamerlingh Onnes found that the resistivity of mercury dropped steeply when cooled from  $4.27^{\circ}\text{K}$  to  $4.22^{\circ}\text{K}$ . The temperature at which a material goes superconducting is called the "critical Temperature  $T_c$ ". It was further established by Meissner and Oschenfeld that a perfect superconductor is a perfect diamagnet. This property goes by the name of Meissner effect.

Other physical changes accompanying super conductivity are:

- i) an increase in specific heat
- ii) a fall in thermal conductivity and a small change in volume.

Superconductivity can be demonstrated by inducing in a superconducting ring, a high current that persists almost indefinitely. Superconductivity can be destroyed by a sufficiently strong magnetic field whose critical value, is given by the expression

$$H_c = H_0 \left(1 - \frac{T}{T_c}\right)^2$$

when a current through a superconductor exceeds a certain

value, it melts away. This is not due so much to the high current values as such, but to the fact that the superconductivity is destroyed by the high magnetic field created by the circulating current, exceeding the critical value and the consequent restoration of resistivity to the material. This effect is named after SILSBEE.

The resistance of a superconductor increases with frequency and normal resistance value is reached at a particular critical frequency  $f_c$ , given by the relation  $h f_c = K T_c$ ,  $h$  and  $K$  being the Plank's and Boltzmann's constants.

Metals like Silver, Gold and Copper which are highly conducting at normal temperatures are not superconductors, whereas good superconductors like Titanium, Niobium and Zirconium have high resistivities at room temperature. Isotopes have different critical temperatures, following the rule  $M^{\frac{1}{2}} T_c = \text{constant}$ ,  $M$  being the isotopic mass. Certain materials like Bismuth under pressure and others when made into thin films exhibit superconductivity. Compounds and alloys of non-superconducting metals, themselves are superconductors. These are classified as "hard" and characterised by high  $H_c$  high  $T_c$  and show incomplete Meissner effect. Soft superconductors become hard when strained or rendered impure.

Some of the more important applications of super-conductivity are:

- i) Power Transmission and Loss Less permanent magnets
- ii) I.V. Measuring instrument ( $10^{-12}$ V)
- iii) High frequency equipment like oscillator and mixers
- iv) Sensitive radiation detectors
- v) Electromechanical devices like motor for instrumental operation
- vi) Tunnelling super-conductor junction as a switch or amplifier.
- vii) Computer applications in switching and storage devices.

The problem of production and measurement of very low temperatures near  $0^{\circ}\text{K}$  is closely associated with work on super-conductivity and is to be perfected.

## DIGITAL STUDIES OF POWER SYSTEMS - LOAD FLOW STUDY

V.N. SUJEER

### INTRODUCTION

This is one of the two papers on the application of the Digital Computer methods to the solution of problems relating to Electric Power Systems. One type of study is the planning and design of a suitable network to meet the growing power demands of a particular region for the next 15 to 20 years. From a comprehensive load survey both the real and reactive power can be estimated at the various load centres of the region. From past experience a tentative network of generating stations, transformers, transmission lines, reactors and condensers is planned. This proposed network is solved for its unknowns by doing a load flow study. The power flows in various transmission circuits and the reactive power at various busses are calculated and these are checked for abnormality. Then suitable changes are made in the configuration of the network if necessary and a fresh load study is carried out. In this way the load flow study aids in the planning and development of future systems.

### THE PROBLEM

The following list of data is known or assumed:

- i) All the series and parallel parameters of the network such as impedances of lines, transformers and line charging capacitors.

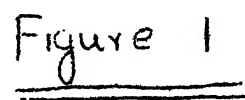


Figure 1

ii) The generating capacities of all generating stations together with their reactive kVA range and the magnitude of voltages to be maintained at the generating stations.

It is required to have complete terminal information at each bus (or node or load centre) i.e. real and reactive power, voltage magnitude and phase angle. To calculate only the losses in the system this much of information is sufficient. However, the calculation of individual line flows can be done, if desired.

#### APPROACH TO THE PROBLEM

Consider the sample system shown in Figure 1. Busses 1 and 2 are connected to generators, busses 3 to 6 are loads. Branches 1 to 7 are line impedances and transformer equivalents Branches 8 to 10 represent line charging capacitors. The neutral is taken as the reference BUS.

In solving such problems one generator bus is taken as a swing bus and this is assumed to account for the losses in the system. The power input at this bus is calculated only after the voltage solution is obtained at all the remaining busses. Voltage at this bus is assumed in its complex form.

If the problem is approached in a nodal basis, the total number of variables is 12 (six node currents and

six voltages). Of these voltage at the swing bus is known. The node equation  $I = Y E$  gives 6 linear simultaneous equations. The relation  $P_n + j Q_n = E_n I_n$  (where  $n = 3$  to 6) gives 4 nonlinear equations. A similar equation at the generator bus which is not a swing bus gives one more non-linear equation. In such a closed form of the equations an iterative solution, which is a repetitive process, is resorted to. Such a procedure involves an initial guess of the voltages. The set of linear equations are used to find the currents. The correction factors for voltages are obtained by the use of nonlinear equations. These correction factors are added to the initial estimate. Now an iteration is said to be completed. These corrected values are again used to find another set of correction factors by repeating the entire process. The repetition of iteration is stopped when all the correction factors have become less than a specified minimum say 0.0005. Then the process is said to have converged and the results are accurate to the third decimal place. This method of successive approximations is very much analogous to the consecutive adjustments of the voltages in an a.c. network analyzer.

The unique facility available in the digital computer is that in a particular iteration itself the correction factor for a particular bus voltage can be

added to the bus voltage immediately as it is calculated and the new corrected voltage is used for the calculation of the next bus voltage. Also a desired accuracy of the results can be easily obtained eg. as low as  $\pm 5 \times 10^{-7}$ .

The greatest advantage to Electricity undertakings and power utilities is that once a general programme is prepared and checked for a representative problem it can be used thereafter any number of times for different networks. A study at any future date can be done by punching a new set of data cards only and running this new data with the previously prepared programme in the computer.

#### THE PROCESS

The process can be divided into the following three parts:

i) Preparation of admittance matrix containing the self and mutual admittances of all the busses.

ii) The iterative method of voltage solution, i.e. the admittance values obtained in (i) are used for the calculation of voltages by an iterative process. When the voltages have converged to the required accuracy the iterations are stopped.

iii) Calculation of terminal information and individual line flows. In this part the final computation of complete terminal information, i.e., real and reactive power, voltage magnitude and phase angle is



carried out.

In the preparation of the admittance matrix the computer processes a list of lines, transformers and capacitances of the system and constructs the matrix element by element. A branch need not be assigned a number. It can be represented by the numbers of the busses at its two ends. The data regarding the first branch in the input list is read, its impedance is inverted to admittance and then the terminal information of the branch is considered. The branch may fall into any one of the three types.

TYPE 1 - the branch may connect some bus to the neutral

TYPE 2 - the branch may connect two busses.

TYPE 3 - the branch may connect two busses and may represent a transformer with off-nominal turns ratio.

If the branch belongs to the first type its admittance is simply added to the self admittance of the bus to which it is connected. For the second type the admittance is added to the self admittances of the busses at the two ends of the branch. Further, the negative of the admittance is added to the mutual admittance between the two busses. For the third type of connection suitable values of self and mutual admittance of the two busses are calculated. The computer selects the particular

routine automatically depending upon the type of connection of the branch. Any addition to the existing system can be done easily by simply feeding a new list containing the data regarding extra lines only together with the matrix calculated previously.

A branch is identified by the numbers of the busses to which it is connected. For example a branch connected to nodes L and K is entered in the list of lines as

L      K      R      X

To avoid confusion and repetition the number L is always to be less than the number K. The data concerning the off nominal turns ratios and numbers of the busses which are connected to such branches are fed in separately.

Next a list of the specified values of the busses is prepared. Three kinds of busses are met with in load flow problems. These are:

i) Swing bus in which the voltage is specified in the complex form. This is a bus connected to a generator.

ii) Voltage specified busses in which the voltages have to be maintained at particular magnitudes in addition to the real power input to these busses having been specified. These are usually busses connected to generators.

iii) Load busses which have a specified real power and reactive voltamperes.

In a case when both load and generator are present at a bus the generator reactive power loading is obtained from the final iterative solution by a suitable combination of the net reactive input to the system given by the solution and the scheduled load reactive power consumption. When a bus is not connected to a load or generator it is a passive node and it is represented by the specification of zero impressed quantities.

To start with a trial set of voltages are chosen, the network conditions are applied to it and the correction factors are obtained. This process is repeated until correction factors reduce to a value less than the specified one, when, it is said to have converged to a solution correct to  $\pm$  the specified value. This correct solution will then satisfy the prescribed terminal condition to the desired accuracy. All quantities such as voltages, currents, real powers and reactive power are dealt with in per unit. Computation involving complex quantities is broken down to that of respective real and imaginary parts. Conversion into polar form is done when the computation of line flows is taken up.

The node currents, voltages and power are related by the following equations: Where,

$$I_K = \sum_{m=1}^N Y_{Km} E_m = \sum_{m=1}^N (G_{Km} + j B_{Km}) (e_m + j f_m)$$

$$a_K = \sum_{m=1}^N (G_{Km} e_m - B_{Km} f_m)$$

$$b_K = \sum_{m=1}^N (G_{Km} f_m + B_{Km} e_m)$$

where  $I_K = a_K + j b_K$  is the current at node K  
 $E_m = e_m + j f_m$  is the voltage at node m

$Y_{Km} = G_{Km} + j B_{Km}$  is the admittance between nodes  
 k and m.

N is the total number of busses.

At a load bus where real and reactive power are specified  
 the equations are as follows:

$$I_K = \sum_{m=1}^N Y_{Km} E_m$$

$$V_K^* I_K = P_K - j Q_K$$

$$\frac{P_K - j Q_K}{V_K^*} = I_K = Y_{KK} V_K + \sum_{m=1}^N Y_{Km} E_m \quad \text{where } m \neq K$$

$$\text{or } V_K = \frac{I}{Y_{KK}} \left( \frac{P_K - j Q_K}{V_K^*} - \sum_{m=1}^N Y_{Km} E_m \right) \quad \text{where } m \neq K$$

At a bus where voltage magnitude rather than reactive  
 power is specified, the real and imaginary components of  
 the voltage for each iteration are found by first computing  
 a value for the reactive power from the following equation

$$Q_K = - \text{Imaginary part of } \left[ V_K^* (Y_{KK} V_K + \sum_{m=1}^N Y_{Km} E_m) \right]$$

Reactive power  $Q_K$  is evaluated for the best previous  
 voltage value at the bus and this value of  $Q_K$  is sub-  
 stituted in the equation for  $V_K$  mentioned previously.

The corrected complex voltage can be calculated to have the specified constant magnitude.

Details of the procedure are as follows:

- i) The process is initiated by assuming a set of estimated voltages  $E_K = c_K + j f_K$  for all the busses other than the slack generator. These values can be taken as  $1 + j0$  for convenience. The voltage of the slack generator bus (numbered as 1) is known completely in complex form and this complex value is used throughout.
- ii) This set of initial values are used in equations mentioned above to calculate the currents at bus 2. This value of  $I_2$  is used with the original estimate of  $E_2$  to compute the power input to the systems at bus 2.
- iii) The calculated power is compared with the stipulated power and this information along with the other condition i.e. reactive power specified in case of load busses or voltage magnitude specified in case of generator busses is used to find out the appropriate corrections to the voltage of bus 2. This correction is obtained on the basis that other bus voltages remain constant when a correction is made.
- iv) The correction obtained is added to the original estimate of  $E_2$  and this new value of  $E_2$  together with the original estimated values of other voltages are used to compute the current at node 3. This current is used to obtain power at node 3.

v) Step 3 is repeated to compute correction in the approximate value of  $E_3$ .

This process is continued upto the end of the list of busses. An important point in the procedure is that as each voltage is corrected, this corrected value is used immediately to calculate the current and hence the voltage at the next bus. With the last bus voltage correction obtained one iteration is said to have been completed and this iteration has provided us with a better estimate of bus voltages. The iterations are repeated until the corrections in all the busses become less than a precision index.

The correction routine depends on the type of bus. The correction of a voltage means a simultaneous correction of two quantities. For example, at a load terminal the computed current  $I$  with the approximate voltage  $E$  will produce in general both reactive and real power loading and it is desired to determine a correction in both the real and imaginary parts of the voltage. Further, a change made in either the real or imaginary part of the voltage will alter both the real and reactive powers. The scheme mentioned here involves the solution of two simultaneous equations each time either a load or generator bus is corrected.

A study of the sample system on the IBM 1620 Digital Computer at this College gave the following results:

Terminal information:

Bus No.	V Real	V Imag.	Volts	Degrees	Power	Reactpow
1	1.050000	.000000	1.050000	0.000000	0.95222	.43333
2	1.098110	-.064453	1.100000	-3.359104	0.50000	.18512
3	.975722	-.221437	1.000534	-12.786517	-.55000	-.13000
4	.915934	-.158813	.929600	-9.836668	.00000	.00000
5	.898040	-.196418	.919269	-12.337375	-.30000	-.18000
6	.898180	-.194861	.919074	-12.240687	-.50000	-.05000

Power Loss = 102224

#### LOAD FLOW INFORMATION

K	M	$\frac{K}{MW}$	To	$\frac{M}{MVAR}$	$\frac{M}{MW}$	To	$\frac{K}{MVAR}$
1	4	.509144	.270372	-.485030			-.158842
2	6	.443081	.202532	-.416602			-.091020
3	3	.171754	.000094	-.154128			.025504
2	5	.328246	.185356	-.295128			-.110194
3	4	-.395870	.597173	.395870			-.535173
4	6	.089158	.004640	-.088263			-.000886
5	6	-.004871	.000615	.004871			-.000607

# DIGITAL STUDIES OF POWER SYSTEMS - SHORT CIRCUIT STUDY

V.N. SUJEER

## INTRODUCTION:

One other problem met by the power engineer in system planning is the short circuit study. This is done with a view to obtain the data required for correct relaying and to determine the size of circuit breakers. This paper deals with the simulation of a three phase fault on a desired bus at a time. For each fault the voltage of the station bus and the current in each circuit are generally obtained in the polar form.

## METHODS OF FAULT STUDY:

The two digital methods suggested so far for the study of symmetrical three phase fault study are:

- i) the nodal iteration method and
- ii) the matrix method.

The nodal iterative method consists of writing one equation for each bus at which voltage is unknown. The set of simultaneous equations formed are solved by digital computer using the Gauss-Seidel Iteration Method.

In the second method matrix operations are made by the digital computer on the impedances of branches that form loops of the network. After forming the short circuit matrix, the necessary output information can be obtained with simple arithmetic operations.



The nodal iteration method using the computer is dealt with as indicated below:

#### BRIEF MATHEMATICAL BACKGROUND:

Consider a set of  $N$  linear simultaneous equations:

$$\begin{array}{rcl}
 a_{11} x_1 + a_{12} x_2 \dots + a_{1n} x_n & = & C_1 \\
 a_{21} x_1 + a_{22} x_2 \dots + a_{2n} x_n & = & C_2 \\
 \dots & & \dots \\
 a_{n1} x_1 + a_{n2} x_2 \dots + a_{nn} x_n & = & C_n
 \end{array} \quad (1)$$

Rewriting

$$\begin{array}{rcl}
 x_1 & = & \frac{1}{a_{11}} (C_1 - a_{12} x_2 \dots - a_{1n} x_n) \\
 x_2 & = & \frac{1}{a_{22}} (C_2 - a_{21} x_1 \dots - a_{2n} x_n) \\
 \dots & & \dots \\
 x_n & = & \frac{1}{a_{nn}} (C_n - a_{n1} x_1 \dots - a_{nn-1} x_{n-1})
 \end{array} \quad (2)$$

Gauss-Seidel method of solving these equations is as follows. Assuming first the values for  $x_1 = x_2 = \dots x_n = 0$  a new  $x_1$  is used with  $x_3 = x_4 \dots x_n = 0$  to determine new  $x_2$  from the 2nd equation of (2). This process is continued upto the last equation (2).

At the end of first iteration  $x_1, x_2, \dots, x_n$  will have a set of new values different from the starting values to obtain another set of new values. The process is repeated many times and it is said to converge if calculated values after an iteration differ from values obtained in a previous iteration by an arbitrarily chosen small value.

The convergence is assured if the diagonal terms of the coefficient matrix are sufficiently greater than the off diagonal terms. The necessary condition to be satisfied for each is that the modulus of the diagonal term should be greater than or equal to the sum of the modulus of the off diagonal terms. In the present study the coefficient matrix being the admittance matrix the above condition is satisfied.

In an  $N + 1$  node network with  $P$  parts, the numbers of independent node equations is  $N+1-P$ . If  $P=1$ , then the number of independent equations are equal to  $N$ . Consider the  $K^{th}$  node. Using Kirchhoff's current law, the following nodal equation can be written.

$$\begin{aligned} (E_K - E_1)Y_{K1} + (E_K - E_2)Y_{K2} \dots (E_K - E_{K-1})Y_{KK-1} \\ + (E_K - E_{K+1})Y_{K+1} \dots + (E_K - E_n)Y_{Kn} = 0 \end{aligned} \quad (3)$$

where  $E$  represents the voltage with respect to reference node,  $Y_{K1}$  admittance between node  $K$  and node 1 etc.

Equation 3 can be written as

$$E_K \sum_{j=1}^N Y_{Kj} - \sum_{j=1}^N E_j Y_{Kj} = 0 \text{ where } j \neq K \quad (4)$$

Similarly for  $K+1^{\text{th}}$  node, we have,

$$E_{K+1} \sum_{j=1}^N Y_{K+1j} - \sum_{j=1}^N E_j Y_{K+1j} = 0 \text{ where } j = K+1 \quad (5)$$

In this manner  $N$  equations can be written for  $N$  nodes putting

$$\sum_{j=1}^N Y_{Kj} = Y_{KK}, \text{ equation 3 can be written as}$$

$$E_K Y_{KK} - \sum_{j=1}^N E_j Y_{Kj} = 0 \text{ where } j \neq K \quad (6)$$

In a matrix form these can be rewritten as

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} & \dots & -Y_{1n} \\ -Y_{21} & Y_{22} & -Y_{23} & \dots & -Y_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ -Y_{n1} & -Y_{n2} & \dots & \dots & Y_{nn} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ \dots \\ \dots \\ E_n \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \dots \\ \dots \\ 0 \end{bmatrix}$$

The admittance matrix is an  $N \times N$  symmetric matrix while the remaining are column matrices.

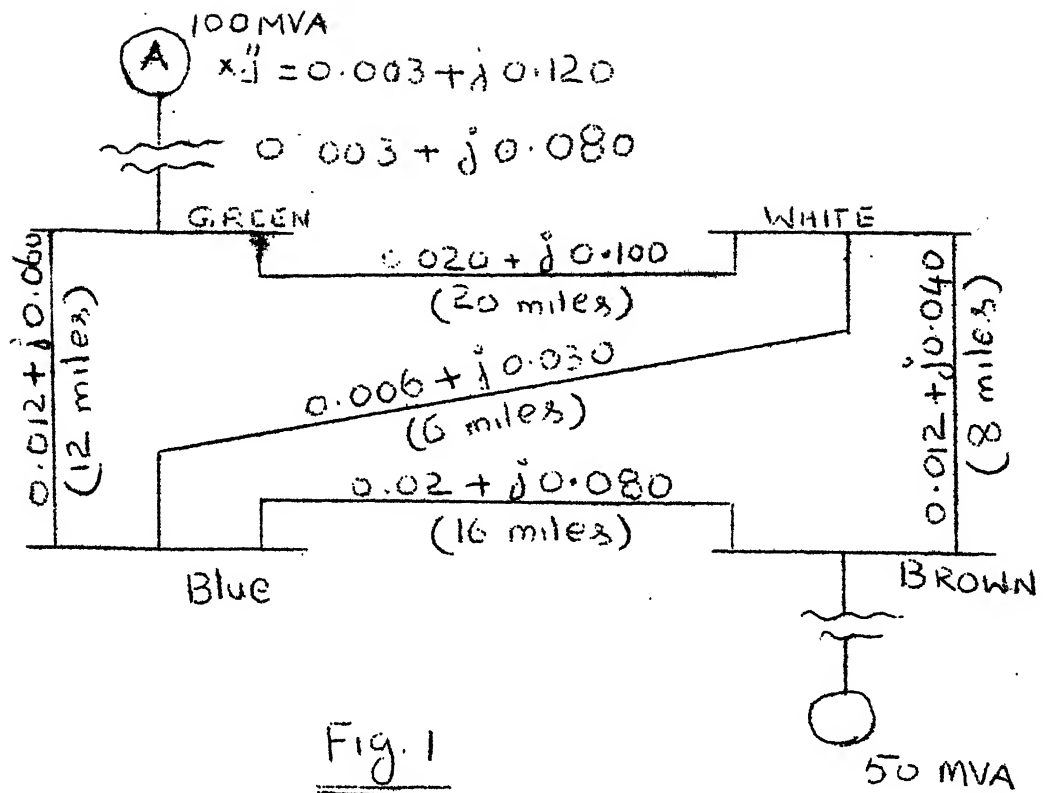


Fig. 1

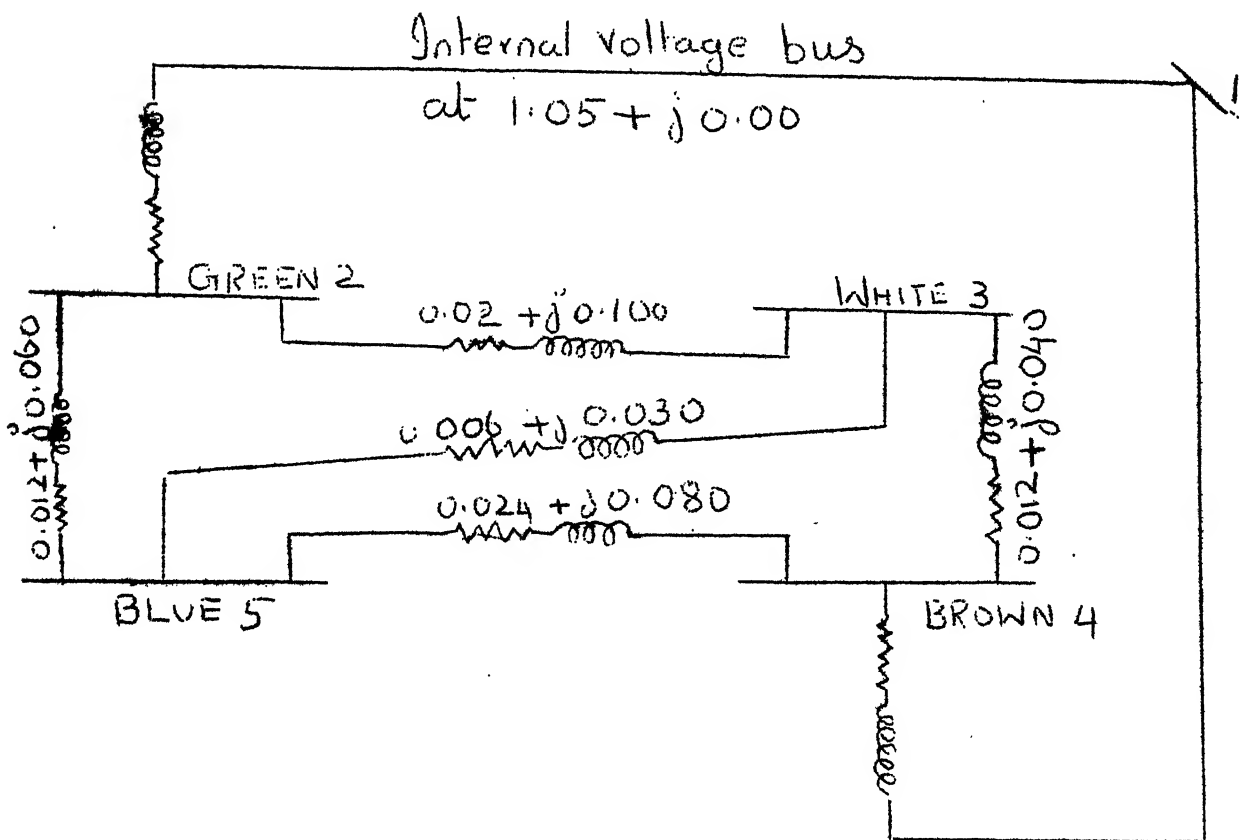


Fig. 2

100 MVA BASE

In fault study a generator node is situated between the subtransient reactance and the internal emf. Equations are not solved for busses at which voltage is known.

#### FAULT STUDY:

Consider the sample system shown in Fig. 1 consisting of two step down stations identified as white and blue, fed over separate lines from a 50 MVA generator at station identified as brown and a 100 MVA generator at station identified as green. All impedance values are converted to per unit 100 MVA base.

For simplicity the internal voltage behind the subtransient reactance of each generator is assumed equal to  $1.05 + j 0.00$  per unit. This enables the representation of both machines by one bus. The system is now represented in Fig. 2.

Consider a three phase symmetrical fault on green bus having the node number 2. The faulted bus will be at ground potential i.e.  $0 + j0$ . Voltages of the remaining busses are initially assumed to be  $0.5 + j 0.00$  and equations can be written in matrix form. Three voltages are unknown and these can be solved by the Gauss-Seidel iteration method.

A three phase symmetrical fault can be simulated anywhere on the transmission line. The fault current can be calculated by treating the faulted point as one

more node. The new admittance matrix can be formed by adding one more row and column to the previous one.

If at a future date two busses are to be connected by means of a transmission line and a fault study is to be made, it would be sufficient if the corresponding rows and columns are altered in the admittance matrix.

#### IMPORTANT ADVANTAGES OF A DIGITAL CALCULATION

##### SINGLE CASE AVAILABILITY:

The loss of time in running an isolated case is very small compared with the replugging time on an a.c. network analyser. Thus once the admittance matrix is formed for a network a record of this can be had in the form of punched cards, magnetic tape etc. If at a future date any load bus or generator is added or removed the admittance matrix can be altered by making the necessary alterations for the corresponding row and column unlike as in a network analyser, where the entire network has to be set up once again.

##### REDUCED ENGINEERING MAN-HOURS:

Digital computations which use standard programmes can be prepared by the engineer before the time of actual computer use. The attendance of the engineer is not required during the calculation.

**HIGH ACCURACY:**

High accuracy, for example, upto 8th decimal place can be obtained.

**ELIMINATION OF ERRORS:**

A modern digital computer can be operated without error for a much larger period than that required for a practical network calculation. Input data for digital computer may be printed so that it is available for checking before and after the calculation has been made.

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## GAUSS-SEIDEL ITERATION

One such iteration method is that in which the  $i^{\text{th}}$  equation in a set of linear equations.

is solved for  $x_1$ . Thus equations (1) are rewritten as

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An estimated value for each  $x_i$  is substituted into equation 2 and new values of the  $x_i$  calculated thereby. This process is repeated, replacing the  $x_i$  estimates by the newly calculated values. The process may be terminated when the new values calculated do not differ from the previously calculated values by more than some arbitrarily specified value.

The original estimated values may be calculated in some manner. One method of calculation of these estimates which is particularly applicable if the diagonal terms,  $a_{kk}$ , in the coefficient matrix are large relative to the non-diagonal terms;

$a_{kj}$ ,  $j \neq k$ , is to calculate  $x_k$  as

$$x_k = \frac{b_k}{a_{kk}} \quad (3)$$

#### EXAMPLE:

Use the iteration method described above to find the first four estimates to the solution of the set of equations.

$$4x_1 + x_2 + 2x_3 = 2$$

$$2x_1 + 6x_2 + x_3 = 3$$

$$x_1 + x_2 + 4x_3 = 1$$

carry calculations to six decimals.

SOLUTION:

A first estimate, by Eq.3 is

$$x_{11} = \frac{2}{4} = 0.5$$

$$x_{21} = \frac{3}{6} = 0.5$$

$$x_{31} = \frac{1}{4} = 0.25$$

For this problem, Eq.2 can be written as

$$x_1 = \frac{1}{4} [2 - x_2 - 2x_3]$$

$$x_2 = \frac{1}{6} [3 - 2x_1 - x_3]$$

$$x_3 = \frac{1}{4} [1 - x_1 - x_2]$$

Using the first estimates in this set of equations gives

$$x_{12} = \frac{1}{4} [2 - 1(0.5) - 2(0.25)] = 0.25$$

$$x_{22} = \frac{1}{6} [3 - 2(0.5) - 1(0.25)] = 0.291667$$

$$x_{32} = \frac{1}{4} [1 - 1(0.5) - 1(0.5)] = 0$$

A third estimate is found, by using the last values of the variables in Eq.2, as

$$x_{13} = \frac{1}{4} [2 - 0.291667 - 0] = 0.427083$$

$$x_{23} = \frac{1}{6} [3 - 0.5 - 0] = 0.416667$$

$$x_{33} = \frac{1}{4} [1 - 0.25 - 0.291667] = 0.114584$$

Finally, a fourth estimate is

$$x_{14} = \frac{1}{4} \left[ 2 - 0.416667 - 0.229168 \right] = 0.338542$$

$$x_{24} = \frac{1}{6} \left[ 3 - 0.854166 - 0.114583 \right] = 0.338542$$

$$x_{34} = \frac{1}{4} \left[ 1 - 0.427083 - 0.416667 \right] = 0.039063$$

The solution to this set of equations by the direct method of determinants, is found to be, to six decimal place accuracy,

$$x_1 = 0.376623$$

$$x_2 = 0.363636$$

$$x_3 = 0.064935$$

An examination of the estimates indicates that the process seems to be a converging one in this case.

In a variation of the general method described above, the most recently calculated value of a particular  $x_k$  is used in all subsequent calculations in contrast to the use of a given set of estimated values in the total set of equations. This method is often called the GAUSS-SEIDEL method, or simply the SEIDEL method. This method, when it is convergent, converges more rapidly than the previously described general method.

EXAMPLE:

Same as the one given for the general method.

## SOLUTION:

Using the first estimates as found in previous examples, a first time through the set of equations, equation 2, gives the values:

$$x_{12} = \frac{1}{4} [2 - 1(0.5) - 2(0.25)] = 0.25.$$

$$x_{22} = \frac{1}{6} [3 - 2(0.25) - 1(0.25)] = 0.375$$

$$x_{33} = \frac{1}{4} [1 - 1(0.25) - 1(0.375)] = 0.09375$$

A second and third application of the process yields

$$x_{13} = \frac{1}{4} [2 - 0.375 - 0.1875] = 0.359375$$

$$x_{23} = \frac{1}{6} [3 - 0.71875 - 0.09375] = 0.364583$$

$$x_{33} = \frac{1}{4} [1 - 0.359375 - 0.364583] = 0.06901$$

$$x_{14} = \frac{1}{4} [2 - 0.364583 - 0.138022] = 0.374349$$

$$x_{24} = \frac{1}{6} [3 - 0.748698 - 0.06901] = 0.363715$$

$$x_{34} = \frac{1}{4} [1 - 0.374349 - 0.363715] = 0.065484$$

Comparison of the general method and the Gauss-Seidel method indicates that the rate of convergence, of the Seidel method for this problem is more rapid than for the former.

# APPENDIX II

## FAULT STUDY ON THE SAMPLE SYSTEM FAULT CURRENT VALUES IN PER UNIT ON 100 MVA BASE

Faulted Bus	Contribution	IBM 1620 without accelerating factor				IBM 1620 with accelerating factor = 1.6			
		Magnitude	Angle	No. of Iterations		Magnitude	Angle	No. of Iterations	
Green Bus	Total	7.49660000	-37.65387600	28		7.49538260	-87.65602400	24	
"	Generator	5.34816290	-88.28006000	28		5.24816290	-86.28006000	24	
"	White	0.92909664	-86.27588100	28		0.92898607	-86.28377100	24	
"	Blue	1.31938700	-86.13323200	28		1.31927310	-86.13963200	24	
White Bus	Total	6.62355790	-86.47686900	9		6.62370230	-86.47706900	23	
"	Green	2.03439680	-86.57161300	9		2.03342680	-86.57197900	23	
"	Blue	2.18576990	-85.42778000	9		2.18577240	-85.42846100	23	
"	Brown	2.40404000	-87.35057000	9		2.40415110	-87.35008900	23	
Brown Bus	Total	6.55657050	-86.31400600	19		6.55641510	-86.31286500	22	
"	Blue	1.50719220	-84.71565200	19		2.62265790	-87.84303700	22	
"	Brown	2.62265790	-87.84303700	19		2.42833130	-85.65225800	22	
"	White	2.42840160	-85.65472800	19		1.50710930	-84.71456300	22	
Blue Bus	Total	6.66033620	-86.52214900	10		6.66016700	-86.52133000	23	
"	Green	3.10988040	-86.65018200	10		3.10987290	-86.64985000	23	
"	White	2.22504120	-87.43741300	10		2.22494830	-87.43522400	23	
"	Brown	1.32638770	-86.52214900	10		1.32631700	-84.68662600	23	

## EDUCATION AND TRAINING OF A MODERN ENGINEERING STUDENT

S. SRINIVASAN

The Engineering Graduates of modern times will have to face and tackle problems of a type and nature entirely different from those that confronted the graduates two or three decades ago. After the advent of independence, our country is making rapid strides in the technical field. A large number of major industries have been started. However, most of them are joint enterprises in collaboration with some foreign firms or others who hold the technical 'know-how' and are expected to gradually train up our countrymen to hold these key positions. In due course of time, therefore, it can be expected that there will be a number of major industries manned from top to bottom by our own countrymen; also there will be more than one firm manufacturing similar engineering goods. There will then set in a competitive field, to produce articles of highest quality at the cheapest cost. For this the available raw materials in our country will have to be used to advantage by evolving new methods of processing and manufacture and for this purpose again the firms themselves will have to establish research laboratories to conduct pilot projects and it will be the future engineer's job to work out these projects. More and more engineers will, therefore, be required to enter

the field of research and design. To be successful in this field the outlook, training and background for the students will have to be considerably altered. In the present curriculum mostly the students are given in their class rooms a lot of facts and figures and even in the laboratories they are given set experiments with detailed instructions as to what should be done and even what should not be. There is not much scope for them to use their initiative or imagination. The students are being coached up more or less for passing the University Examinations. The students and the faculty are, therefore, more interested in dealing with those aspects only of the subject and training of the students as will be useful and helpful in passing the examination with distinction and not in stimulating the initiative, creative abilities and the imagination of the students. But an engineer to be useful as one, especially as a research or design engineer must have a different type of training. He must get a thorough grasp of the fundamentals of not only in the technical subjects but also in the basic sciences viz. Mathematics, Physics and Chemistry. He must be trained to develop the habit of independent thinking. The subjects must be presented to him in such a manner as to create a love for the subject and a desire to probe further deep into it. It is necessary that a

personal contact be established between the teacher and the student and an opportunity provided for the teacher to find out the special aptitude of the student, the field in which particular student has a natural inclination to develop. It is, therefore, necessary that the students should be given a thorough grounding first in the basic sciences, physics, mathematics and chemistry. Then a variety of Engineering subjects should be offered and the students given the option to select some of them so as to enable them as well as the staff to ascertain the special aptitude of the student. Then he must be given a further training of an advanced and specialised nature in Physics, Mathematics and Chemistry if necessary which will all be required for the proper study, understanding and pursuit of the advanced studies in the special field of engineering of this choice. These Engineering subjects are also to be taught more as applied science rather than what is being done now as engineering subjects giving merely number of facts and figures about apparatus and equipment. In other words what is required of an Engineering Graduate should be that he must be a man who has a thorough and up-to-date knowledge of the basic sciences of Mathematics, Physics and Chemistry that will be useful for the branch of Engineering he specialises in a broad based idea of the apparatus and



equipment he will come across in his field of specialisation and finally a capacity to think for himself and be able to pursue a project or face a problem intelligently and to apply his knowledge in the successful tackling of the problem.

At present in our country most of the Engineering Graduates are being employed on jobs which really belong to the field of technicians or even craftsmen. But if our country is to progress and earn a place in the Industrial map of the world the Engineering Graduates must be given their proper places. The Engineering Colleges and the Universities, the staff and the students must be made to realise what exactly is expected of them and the education and training must be suitably modified.

Even in such an advanced country as the U.S.A., where the technical institutions offer a variety of subjects and provide a lot of opportunities for the students to specialise in the field in which they have a taste and aptitude, the courses, curriculum, etc. are in the process of reorganisation. The Massachusetts Institute of Technology, the foremost technological Institute in U.S.A. has recently introduced a curriculum with a syllabus and scheme of studies which is entirely and radically different from that existing at most of the institutions. The main theme of the scheme

is that Engineering is to be taught as Applied Science. A number of articles has appeared in recent years in the technical journals of U.S.A. by eminent Engineers, Research Scholars and experienced educationists on the urgent necessity for the change and reorganisation the mode and type of Engineering Education imparted to the students in their country.

Dr. J.T. Rettaliata, President of the Illinois Institute of Technology, Chicago has remarked "The prospective engineering student can look forward to more emphasis on sciences and humanities and less attention to applications during his undergraduate days. Specialisation will move to the postgraduate area and it will not be too long before a post-graduate degree is the minimum requirement in Engineering as is the case in the Sciences".

Dr. F.E. Terman, Dean of the School of Engineering and Provost of Stanford University, California in an article entitled "Electrical Engineering Curricula in a changing world" in the proceedings of the American Society of Electrical Engineers, writes:

"In the last decade important changes have taken place in the education of Electrical Engineers ..... The great problem involved in the training of Electrical Engineers of to-day is that there is so much that is

with learning. This comes about because one of the most significant features of present day technology is the extent to which advanced mathematics, academic Physics and high brow engineering can be used to the solution of Electrical Engineering problems of great practical significance to industry.... The young Electrical Engineer of to-day must know more engineering and sciences than was expected 20 years ago.

A number of significant changes are taking place to-day in curricula for training electrical engineers. First, greatly increased emphasis is being placed on the basic sciences and on fundamental engineering principles, with correspondingly less attention devoted to current engineering practice and to drill in design and computation procedures. Second, the undergraduate years are being used with increased efficiency. Third, the time devoted to College training is on the average being extended .....

Electrical Engineers are today rapidly going back to general principles ... No longer is the basic sequence of physics courses in mechanics, heat and electricity considered as providing comprehensive training of engineers in physics; familiarity with atomic and nuclear phenomena and with solid state physics is

rapidly becoming a must for a well trained Electrical Engineer. Similarly mathematics through a smattering of ordinary differential equations no longer represents adequate training for those of our next generation of engineers whose interests are in the more technical matters; these men must know partial differential equations, functions of a complex variable, matrix theory, statistics, numerical analysis, etc...

Several new ideas in Engineering Education are being currently explored. There is for example the 5 year undergraduate programme which was adapted by several engineering schools immediately after the war ... An interesting departure from convention is the comprehensive or unified engineering curriculum. Here there is only one basic engineering programme with instruction so organised as to emphasise the similarities between different areas of engineering, instead of the more customary policy of emphasising the differences ...

One of the great weaknesses of much present day engineering education is that the student commonly is handled as a category rather than an individual ..... It is time that each student be treated as an individual and that consideration be given to his personal ambitions, his likes, his strong points and his weaknesses. Each student needs an opportunity to do some

experimentation with himself and his training in order to obtain the experience and data that will permit him to make a personal inventory ...

The discussion is thus concluded with the thought that one of the most important steps which engineering education can take in the future is to arrange matters so that each student has the opportunity to tailor his curriculum to fit his personal characteristics rather than forced into a predetermined mould that is the same for all students. Lock-step may be alright for criminals, but it is not the best way to train engineers to take responsibility in the world of the future."

The above extracts refer mostly to Electrical Engineers since it is from an article written by an Electrical Engineer for an Electrical Engineering Journal. But the basic ideas and concepts expressed apply equally well to the other branches of Engineering. It is, therefore, necessary that we in India must take early action for imparting the proper type of education and training to the Engineering Students to suit the modern conditions and growth of Engineering & Technology and then utilise these Engineering Graduates in the appropriate fields in a proper way so as to derive the maximum benefit from them for our country.

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PROCEEDINGS ON 21-6-1965

Prof. A.P.JAMBULINGAM, the Indian Counterpart, welcomed the participants and then briefly dealt on the scope of the Summer School.

Prof. FEILREISEN pointed out that development of Engineering should be kept up through Magazines or Journals. He emphasized that contact with industries is also a necessity.

He mentioned about the staff categories existing in U.S. Universities, which are Professors, Associate Professors, Assistant Professors and Lecturers.

He also mentioned that American Universities are autonomous with regard to the syllabus. Students can choose subjects to suit their individual aptitude. He added that the Mechanical Engineering Courses in some of the Universities in U.S.A. are Science-oriented. The syllabi are varied and are subject to changes every two years.

Though the basic ideas remain the same their applications vary frequently. The tool or the fundamentals of fluid mechanics, for example, can be explained best by reference to a unit like the gas turbine.

Prof. Jambulingam mentioned about a system present in some U.K. Universities where an external examiner awards 70% and the internal examiner 30% for a course taught. He also quoted the view of a British educationist, the University education is for a selected few and not for all.

## MECHANICAL ENGINEERING CURRICULUM

W.J. FEIREISEN

The speaker mentioned about the change in the curriculum of Wisconsin University with the needs of the present days. He also compared the Mechanical Engineering curriculum of Jadavpur and Delhi Universities with that of the University of Wisconsin.

He pointed out that the Indian Universities have a high amount of credit hours compared to that of Wisconsin. He said that this may not however mean anything in reality.

He compared the percentage contents of several courses and observed that:

i) the credits in per cent of Mathematics, Chemistry, English, Physics, Thermodynamics, Fluid Mechanics remained very much the same with little variation both in Wisconsin and Indian Universities.

ii) To avoid repetition of certain courses, classical physics has to be eliminated.

iii) Chemistry in Wisconsin is only general in nature and not too qualitative.

iv) The drawing content in Wisconsin curriculum is on the decrease since it is not the aim to create draftsmen.

The absence of courses on speech and technical

writing in Indian Universities was pointed out. He also observed that the main complaint of the industrialists against the present day engineers is that they are unable to write and communicate.

The electives would include any subject even non-engineering.

Surveying could be included under the electives.

S. SUBRAMANYAN pointed out that the Wisconsin curriculum has decreased the emphasis on Design whereas the modern trend in the continent is to have more emphasis on design. To this Feireisen replied that the emphasis is only on the increase though the percentage content has decreased.

To W.G. KOTHANDRAMAN's query Feireisen replied that the course on economics is not confined to engineering only.



## TEACHING THE THERMOSCIENCES

A.P. JAMBULINGAM

W.J. FEIREISEN

A.P. JAMBULINGAM outlined the features of the Thermosciences syllabus in India. He quoted the various figures relating to the content of various subjects in our curriculum. He claimed that thermodynamics is the core of the thermosciences.

W.J. FEIREISEN said that the subjects of thermodynamics, Fluid Mechanics and Heat Transfer would come under Thermosciences. He stressed the need for teaching the subject of Fluid Mechanics by the faculty of Mechanical Engineering to the students of Mechanical Engineering. He felt that Civil Engineers do not emphasise the compressible flow as their studies are confined more to Hydraulics. He pointed out a number of suitable text books. He defined a good text book as one which when read by a student makes him understand the most of it. Steps are now being taken to co-ordinate thermodynamics, heat transfer and fluid mechanics by the use of common symbols etc.

W.J. Feireisen in reply to a query from S. Subramanyam said that he also included Mass transfer whenever he mentioned Heat Transfer.

Replying to A.P. Jambulingam's query Feireisen said that the content of Thermosciences was pretty much

the same for students of Production Engineering also.

S. NARASIMHAN pointed out that we lose the physical concept when the problems are approached through vector analysis. W.J. Feireisen agreed to this, but he pointed out that for certain problems vector analysis would be essential.

## TEACHING OF MACHINE DESIGN

R. SAMUEL

The topic, we have chosen for this after-noon's discussion is "Teaching of Mechanical Design". I request you to kindly pardon me if I do not dwell at large on Mechanical Design, but shift to Teaching Machine Design. The two are not exactly the same, as would be made clear during the course of my talk. I have deliberately deviated a little from the original topic, as I feel a better perspective would be obtained that way. To start with, we would like to understand the significance of machine design in the national industrial development and economy, then in the Mechanical Engineering Curriculum in teaching institutions and then pass over to the teaching of machine design.

### MACHINE DESIGN AND THE NATIONAL ECONOMY

Machinery form the back-bone of any industrial structure and to have a higher pace of industrialisation, the country needs more machinery. Machinery when imported drains the country's economy or renders it dependent on others and to avoid both we have to build our own machinery. This can be done to an extent, if we have the know-how in the fields of production and fabrication and materials sciences, by merely copying old machines made abroad if their patents have lapsed, or by buying

designs from abroad and making the machines locally or by gradually developing our own designs. This last method is therefore the proper solution, as it at once boosts up our economy, brings the country to a stage of self-reliance and places it in a prestigious position. Thus we see that designing and making our own machines has now become imperative.

#### MACHINE DESIGN IN THE CURRICULUM:

If we take a different perspective and look at the subject of Machine Design from the point of view of Mechanical Engineering Curriculum in a teaching institution we are well aware that along with Power, Production & Transportation, Machine Design is one of the basic fields of study in Mechanical Engineering, in its own right.

#### TEACHING MACHINE DESIGN:

We shall now move over to the Teaching of Machine Design. There are two aspects to this problem. One is what to teach? and the other is how to teach? The basic techniques under the latter head have been discussed by various speakers at the last Summer School and would perhaps be taken up by others during the current school. I shall, therefore, restrict myself to the first aspect, i.e. what to teach? Before we go into the details of it, it will not be out of place here to define certain terms

with a view to appreciate the significance and scope of the subject better.

#### WHAT IS A MACHINE?

Machines are normally defined as a constrained combination of resistant bodies meant to transform motion or transfer energy and do work according to certain prescriptions. This definition, no doubt was true earlier (if we take purely mechanical machines), but now, I should say, is not quite precise, comprehensive or appropriate in many instances. The earlier definition assumes machine elements consisting of purely mechanical links. If we accept this definition then our field is unduly circumscribed, as today we have machines consisting not only of mechanical elements but also of electrical, electronic and other elements - elements which are not restricted to transferring motion and force alone, but also elements meant for memory, logic and decision, for control and regulation, built into machines as integral parts of them, such as transfer machines, programme controlled machines, automatic packaging and processing machines, etc. So the old definition is no longer valid in this sense, if we are to take a realistic picture of today's machines. We could therefore define a machine as a unit or combination of units built up in such a way

that the ultimate object is to obtain, modify or control either motion or force or both (or equivalents like energy, etc.) satisfying or obeying the commands or prescriptions which we might impose and function as a system, perhaps as a self correcting system. So, hereafter, I shall mean such systems, when I say machines. Such machines, have therefore, many more kinds of elements and units than simple conventional machines. According to the earlier definition even a simple lever or a gear box is a machine. But we shall call them as trivial machines and take a look at more complicated machines. Machines tend to get automated with increasing complexity. Table I shows a classification of the order of the machines as given by Amber Brothers Inc.

#### NOW, WHAT IS MACHINE DESIGN?

It is the creation of a new or better working machine - a machine and not a component. Quite often we in our Colleges talk of machine design, when we actually mean design of machine elements, as when we obtain the proportions and dimensions for a Knuckle Joint or a coupling and so on. But we as teachers should mean the principles of design of the whole machine and not a component design when we say machine design.

#### WHAT TO TEACH:

If we say we are going to teach machine design, we should be aware of what a designer of machines ought to know. Let us follow with the help of Table 2 the process by which a design is developed and thereby make things clearer - what are the different aspects of design? and what are the fields of knowledge necessary therefor? This would give us a better perspective of the inter-relationship and significance of the various subjects and other requirements.

#### STAGES OF DESIGN:

The design of a machine starts with:

i) the precise and complete Prescription of the functions the machine is expected to perform. This is largely done by the administration based on Economic considerations, their market research and marketing policy.

ii) The second stage is Process Fixation. That is to say the particular process by which the above mentioned demands could be met, would be chosen from among a number of alternatives, eg. If Shoe Polish were to be sold in containers and if machinery were to be made for the same then the Shoe Polish may be packed in tin containers or in collapsible tubes like tooth paste. The two alternate suggestions for the process would mean

entirely different types of process and machinery. Thus, fixing the process would apart from depending on the capacities of the manufacturing firm, depend on the alternatives which a designer could offer. The intuition, experience, versatility and originality of the designer are all put to test and all these qualities reflect on his designs.

iii) The third stage consists of the Synthesis of Motion or the system. That is to say a linkage or machine has to be developed to obtain the desired motion without any reference to any force. For non-mechanical elements, this is a stage where units are represented by blocks in a schematic diagram.

iv) The next stage is one of Dynamic Analysis and Proportioning of Parts. Here the various forces are taken into account and a stress analysis is made, as also a study of available materials for the various components. This stage leads to the provisional dimensions of parts. A similar procedure leads to assigning values to non-mechanical elements.

v) At the fifth stage the Behaviour of the entire System obtained above is studied under static as well as dynamic conditions. What is a System? A system is an assembly of units, assembled in such a way that all the units together function in a prescribed way. Here we



are not so much interested in the functioning of the individual units as in the co-ordinated functioning of the whole. The stability and the effects of various disturbances on the system tending to deviate its performance from its equilibrium during operation as well as at rest will here be analysed.

vi) The economic and practical Feasibility of Production or fabrication, assembling, maintaining and dismantling are considered at this stage. If the machine as designed above will not lend itself to any of these then redesigning is done. This step more or less completes the formal and preliminary design.

vii) Now a model or prototype is made and tested to find out how the machine behaves and then

viii) a field test is done under actual working conditions and if it is satisfactory

ix) Production is undertaken

x) The last stage is one of Analysis of Actual Service Data obtained after due time lapse, when the product has gone into the market. From the light of these observations such as relating to wear, corrosion, ageing, unknown loads etc. modifications are carried out on the original design.

The above is a rough and general procedure. It need not be that every design has to pass rigidly through

this scheme. Sometimes the stages cannot be undertaken independently.

#### RELEVANT FIELDS OF STUDY:

To the right of the stages of Design in Table 2 has been listed the relevant fields of study where instruction has to be imparted to the student. The listing is self-explanatory and the significance of the various disciplines are obvious. But as yet, some of the subjects have not yet been given the importance they deserve.

#### TYPE OF INSTRUCTION:

In Table 2 is also indicated the type of instruction, which in my view would be suitable for the corresponding subject. The curriculum should be planned in a co-ordinated way. It is an unfortunate situation that even among most Western Institutions, the proper degree of coordination is still lacking\*. This point should be given due consideration. Emphasis is to be laid throughout more on learning and self-development rather than on being taught. This has to be necessarily so in the case of creative steps such as the stage of process fixation.

#### A LIST OF SUBJECTS:

Table 3 gives a list of all the subjects mentioned in Table 2. We could perhaps have elective groups in these subjects to reduce the number of subjects a student

\*eg. Refer to the Preface of "Fundamentals of Machine Design" by Prof. Richard M. Phelain, Cornell University, McGraw-Hill, 1962.

has to choose.

#### TIME REQUIREMENTS:

For a person to be trained adequately in the various subjects as indicated in Table 2 considerable time is required. There are two alternatives - one is to build up on what has been done at the Under-Graduate level during a Post-Graduate course and the other is to bifurcate the Under-Graduate course in Mechanical Engineering itself into suitable branches with appropriate electives. That would mean an elective group with specialisation along the line of subjects indicated. With some slight modifications of our existing systems we could introduce and accommodate such a step. This might be contradictory to the policy of retaining the U.G. course in Mechanical Engineering as a general Mechanical Engineering Course without specialisation in any particular field. But the field of Mechanical Engineering, being so vast as we see it today, the sooner such a division takes place the better it would be.

#### STAFF REQUIREMENTS:

Table 3 lists related subjects in groups. It would be best if persons engaged in teaching were to confine themselves to such related subjects so that they could be of effective use to the student community as well as

be more productive in their own fields. For many of the subjects listed qualified teachers are available in each College. Teachers, especially belonging to the field of machine design must have first hand knowledge of what is actually happening in the industry. They should, therefore, be permitted to undergo occasional practical training in the industry, encouraged to visit varied establishments and even work in the industry for short duration, say during the vacations. Only then will they be aware of what is actually happening and contribute positively to the student community and to the state and thereby benefit themselves in the process.

TABLE 1\*

Order of auto- maturity	Essential Characteristics	Examples
0	Elementary tools replacing no human energy or control	Pliers
1	Power operated but manually controlled and fed machines	Electric Drill
2	Power operated but with only on-off control by human effort but work must be set up	Shaping Machine
3	Open loop self-acting machines	Turret Lathe
4	Closed loop feed-back controlled machines where performance is compared to a standard	Governing of engines
5	Machines using computing devices where control is based on solution of equations	Gun Turret Control
6	Machines where control is based on automatic solution of logic functions	Telephone equipment
7	Machines that learn from mistakes and attempts different modes of operations as necessary	
8	Machines that can extrapolate from previous experiences	
9	Machines having creativity or originality to come up with new concepts	
10	Machines having all above potentials plus ability to give orders to human operators or designers	

\*Extract of Table by  
 Amber G.H., and Amber, P.S., "Measuring Automation"  
 SAE Journal, July 1957.

TABLE 2

Stages of Design	Demand knowledge of or require	Which can be impaired by
1. Function Prescription: define performance expected of machine	Market Research and Analysis Industrial Economics	Lectures by leaders of pioneering firms, staff, case studies, journals.
2. Process Fixation: choosing the best process for realising above aims	Intuition, Experience, Versatile originality	Lectures by leading designers, case studies, personality development courses.
3. Motion analysis & Synthesis: Obtaining proper linkages, Schematic block diagrams, etc.	Kinematics Measurement & Instrumentation Principles of automation Network analysis & Synthesis	Lecture, Org., Assignment, Illustration Lecture, Lab., Assignment Lecture, self rdg., Assignment, case studies Lecture, Lab., Assignment
4. Dynamic analysis & Provisional dimensioning: Obtaining proportions and values taking it into account forces & other quantities.	Dynamics of Rigid bodies Dynamics of elastic systems Mechanics of materials inclusive of stress analysis Materials Technology	Lecture, Assignment, Lab.
5. System Analysis, Stability Criteria, etc.	Dynamics of control systems system behaviour analysis	do
6. Planning/checking for economic production, etc.	Materials Tech., Production processes & other economics	Lecture, Assignment, Lab. and case studies Lecture, Lab., Lecture by Production Engrs. from industry
7. Model/prototype building & testing	Model studies, Dynamical Analogies, Theories of Experimentation and Measurement	Lecture, Laboratory, Case studies.
8. Field test under actual conditions	Statistical methods	

TABLE 2 (CONT'D)

9. Actual Production	Design Office Procedures & Techniques Materials Technology Production Processes	Case studies, Lecture by staff & Design Engineers from industry do Lecture, Lab., Visits to Industry
10. Modification of design after analysis of Actual Service Data relating to wear, corrosion, ageing, customers' preferences, etc.	Statistical methods Market Research	Lecture, Assignment, Case studies Lecture by staff and persons from industry, case studies, assignment.

TABLE 3

## A LIST OF SUBJECTS:

Market Research and Analysis  
Statistical Methods  
Industrial Economics

Kinematics  
Dynamics of rigid bodies  
Dynamics of machinery  
Dynamics of elastic systems  
Dynamics of control systems  
System behaviour and Analysis  
Network Analysis and Synthesis  
Principles of automation

Materials Technology  
Mechanics of Materials  
(inclusive of stress Analysis, etc.)

Model Studies and Dynamical analogies  
Engineering analysis

Theories of measurement and experimentation

Production Processes and Economics

Design Office Procedure and Techniques



## DISCUSSION:

i) Is it possible for an undergraduate student, who has not come across automatic machines, to design such machines?

It is not necessary for a student to have seen automatic machines. If he is given the necessary data, he can and must be in a position to design by synthesis and analysis.

ii) Is it advantageous to copy a foreign machine of an automatic type?

It may not be good as some of the complicated motions may not be properly copied retaining the conditions affecting acceleration, inertia, etc.

iii) Is it desirable to have our present curriculum which aims at force analysis changed into one similitude principle using indigenously available components?

Components can be treated separately. Design of machines using indigenous materials may be treated separately.

After the discussion, the film "Structural Testing" was shown.

## INDUSTRIAL ENGINEERING AND MANUFACTURING PROCESSES

H.O.N. JOSEPH

The sum and substance of the course in Mechanical Engineering remained more or less static for a long period until the introduction of the integrated course recently. The fourth plan period aimed at an expenditure of 10 crores for technical development. In the context of the present day developments it is doubtful whether we are giving to our students what they would need when they leave the Universities. Affording facilities for the students to specialise in any one of the fields of Heat Power or Production or Machine Design might be thought of. The time allotted now for Production Engineering is too limited. The students must be trained to produce equipment at the minimum cost with minimum labour with a proper human relationship among the labour. He must have a good knowledge of stores, accounts, production planning and control, labour problems, ability to put his ideas to his superiors and subordinates properly without any confusion, economics of the manufacture of various, production methods, etc. The time allotted to Industrial Engineering was low and inadequate. The syllabus in Industrial Engineering itself should be increased.

## DISCUSSION:

A.P. JAMBULINGAM remarked that Industrial Engineering course could be offered as a separate discipline under "Methods Analysis" or "Managerial Division" or "Production Division".

W.J. FEIREISEN: In the University of Wisconsin, a student could obtain M.S. degree in Mechanical Engineering with a major in a particular field. There was in recent times a great demand for people trained with Industrial Engineering background. In Wisconsin there was a move to bifurcate the Industrial Engineering from Mechanical Engineering. In Industrial Engineering itself there could be an integration of all sub-topics into a single system called "Management System" which would mean a course on Engineering material and men.

However the Engineering student must first receive a broad based education rather than a specialised one.

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## THE ROLE OF THE SHOP AND CO-OPERATIVE PROGRAMMES IN MECHANICAL ENGINEERING CURRICULA

R.P. ARTHUR

The author pointed out that the aims of practical education in workshop are:

- i) Proper understanding of theory
- ii) Achievement of certain amount of personal skill and familiarity with the machines.
- iii) Getting to know the time for certain operations.
- iv) To get ideas about the Engineering materials - machine ability of materials, hardness of materials, speed of cutting etc.
- v) Economics of manufacture
- vi) Mastery of the various processes
- vii) Methods of measurement - accuracy - tolerance
- viii) Ability to read blue prints
- ix) Ability to use the tools correctly
- x) Personal satisfaction of certain achievements of having manufactured a certain piece all by himself.

Regarding co-operative programme, three or four students may be grouped together and manufacture of a machine may be given so that they may co-ordinate their work to achieve a common objective.

## DISCUSSION:

A.P. JAMBULINGAM pointed out that co-operative programme as envisaged in the programmes is co-operation with the industry. If the students could be provided training in industries even while he is studying, it would be of considerable help.

W.J. FEIREISEN pointed out that if staff are employed in industries during summer, they would return to Universities with rich experience.

He also remarked that the students should be given opportunity to complete a job and see it working or being put to use. Motivation in a student will be very useful. In Wisconsin the students are not expected to be in the shop during any definite time. They are given a piece work and asked to complete within a specified time. So with minimum equipment, a large number of students can be trained.

It is not necessary to train students to a high degree of skill since they are mainly to serve as Engineers. They are not to be used as technicians.

The discussions were followed by a film on "Atomic Venture".

## THE MECHANICAL ENGINEERING LABORATORY - CURRICULUM

W.J. FIEREISEN

The speaker said that the objects of experimentation is to:

- i) Illustrate the truths or the laws or the fundamental principles which cannot be dealt well in class.
- ii) Correlate the analytical calculations made in the theory class with experimental values in the laboratory.
- iii) Teach the student to be careful in reading the instruments, etc.
- iv) Gain knowledge and experience to convey his ideas to others by means of a report.
- v) Teach the students to feel the importance of working in a co-operative manner in team spirit in all systems experiment.
- vi) Make the student cultivate qualities of leadership.

## DISCUSSION:

Where there is a tendency for one or two students to copy the work of others, such students should be made squad leaders. The teacher and the rest of the students must deal through this student. Secondly all the students must rotate to read various instruments, instead of one student always reading one instrument.

Students should be required to evolve the method of carrying out the experiment by themselves.

## GRADING AS FOLLOWED IN WISCONSIN UNIVERSITY:

30 Points	:	for turning all reports of experiments in time and get accepted.
40 Points	:	For quiz
20 Points	:	For contents of the reports.
10 Points	:	For general conduct, behaviour etc.

COURSE PROSPECTUS FOR ECPD INSPECTION\*

MECHANICAL ENGINEERING 612-179-2

TECHNICAL WRITING

(3 CREDITS)

a) COURSE CONTENT:

Engineering reports and business communication; practice in planning, preparation, and critiquing of a variety of reports and business letters; emphasis on writing techniques and organization, Mr. Sell, Mr. Elsom, Mr. Esser.

b) PRIMARY SUBJECT AREAS:

Broadly, Formal and Informal reports. The former consists of approximately a month-long project, from original research through information gathering, outlining, rough drafting, to polishing and revising into a finished report. Topic student-selected, to enhance student interest throughout. Informal reports consist of memoranda, long and short; laboratory reports, progress reports; business communications represented by letters of inquiry, answer-to-inquiry, letters of complaint, answer-to-complaint, letters of application; some work in proposal, specification and instructional writing.

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\*As adopted in Wisconsin University



c) TEXT BOOK AND PAGES COVERED:

Sigband, Norman, B., EFFECTIVE REPORT WRITING, Harper Brothers, Publishers, New York (Pages covered indicated on course syllabus enclosed after sheet 2 below. Students hold responsible for everything in the text).

The technical writing course M.E.179(CE 279) is directed toward the development of practical writing skill: Clarity and brevity for engineering material, facility for business correspondence. More time than is available could be spent profitably on the writing problems faced by the engineer; as only one semester's work is scheduled, the student should make the most of the programme.

One major assignment is a formal report. Length and content vary; the student should select a subject significant for his own professional interest. Some reports submitted last semester were deficient because of what may have seemed unimportant details such as typographical errors and misspellings. More serious is the bad sentence: the sentence that does not say what the writer means, that has to be re-read and guessed at, or may be interpreted in a sense far from the writer's intent.

Sentences strung together is wasteful, redundant verbiage mark the writer who has not taken time for polishing and second thought, and suggest that the material represents something less than mature thinking. Dangling constructions and misused pronouns make for confusion, and bad grammar seriously downgrades the engineer's professional status. The student should realize that he will throughout his career be writing for busy people who do not have time to try to read his mind, and that what is put into writing may be very important in regard to differences that may even reach court rooms.

The formal report is submitted first in rough draft. This is to free the student from inhibiting concern about stylistic details, and encourage the flow of ideas. However, it should not destroy concern for the reader, who needs legible material, "one side only", with margins (room for reader comments), in black ink, if handwritten, or good black typeface if typed. Thin paper should not be used.

Emphasis is being placed again on an old rule: after three consecutive absences a student shall be dropped. Certainly three or four unexcused absences, in class or in weekly conference, will prejudice a student's record. Trips for employment interviewing are not valid excuses for incomplete work.

Papers produced for this course will be filed with readers. Each student will provide a manila folder with his name lettered on the tab. Papers will be processed by readers and discussed in conferences. When they have served their purpose, the papers will be initialed by the student, in the upper left corner, with any appropriate comment, to signify that they should be filed. Papers may be corrected, revised, or, with the consent of the reader, rewritten. Papers to be revised should be labelled (corrected, rewritten). and if rewritten a paper should be designated "A Rewrite".

The rough draft of the formal report which has been processed by the reader should be turned in with the final write-up. Papers in the folders will be checked before final grades are set. After grades are posted, students may pick up their folders.

In this course the student should think of himself as a practising engineer; he writes for self-advancement, for an employer, perhaps for stock holders, or for government executives. He should think of his reader as the person he would probably be dealing with in real life, and his assignments in terms of practical realities. This requires a certain amount of imagination and mature capacity for adjustment - both of which should be valuable for his future.

Papers should be endorsed on the back.

Doe, John                    (Your name)

Wed. 8 A.M.                (Your conference day and hour)

Assignment No.            (The number and short title to  
identify)

February, '65              (Date of writing the paper)

Mr. Roe                    (Reader's name)

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ME-179 TECHNICAL WRITING TENTATIVE LECTURE AND ASSIGNMENT  
 SCHEDULE TEXT - EFFECTIVE REPORT WRITING BY .....

FALL SEMESTER 1964-1965

DATE	LECTURE	TEXT ASSIGNMENT	WRITTEN ASSIGN.
Sept.			
15	Objectives of Course	None	
17	Value of Technical Writing	pp. 3.13	
18	Memoranda	pp. 205-214	
22	Readability and Clear Writing	pp. 168-179	
24	Readability and Clear Writing	pp. 183-191	
25	Long Memoranda	Notes	Memorandum
29	Long Memoranda	pp. 322-338	
Oct.			
1	Collection of Information	pp. 16-55	
2	Organization of Material	pp. 96-131	
6	Organization of Material	pp. 56-90	
8	Laboratory Memorandum	notes	
9	Laboratory Memorandum	notes	Investigative memorandum
13	Sentence and Expanded definition	pp.394-400	
15	Technical Description	pp.400-422	
16	Use of Engineering Library	Notes(review pp.16-55)	Laboratory memorandum

DATE	LECTURE	TEXT ASSIGNMENT	WRITTEN ASSIGN.
Oct.			
20	Planning the Long report	Notes	
22	Types and Form of Long Report	pp.264-306	Library Research Memo
23	SIX WEEK TEST		
27	Topic Memo Disucssion: Mechanics of Style	pp.646-676	
29	Mechanics of Style Exercise		
30	Introduction to Long Report		Formal Report Topic memo
Nov.			
3	Body of Long Report	pp.183-200	
5	Terminal Sections of Long Report	pp.407-412	Outline of Body of Formal Report
6	Use of Illustrations (slides)	pp.140-163	
10	Use of Tables & Illustration	Notes	
12	Technical Description Exercise	pp.111-131	Introduction to Long Report (rough draft)
13	Criticism of Reports	Notes	
17	Persuasive Reports	Notes	
18	Persuasive Report Exercise		Body of Formal Report (rough draft)

## 19 TWELVE WEEKS TEST

ME-179 TECHNICAL WRITING TENTATIVE LECTURE AND ASSIGNMENT  
SCHEDULE TEXT - EFFECTIVE REPORT WRITING

FALL SEMESTER 1964-1965

DATE	LECTURE	TEST ASSIGNMENT	WRITTEN ASSIGN.
24	Business Letters: form	pp.501-529	
	THANKSGIVING RECESS		
Dec.			
1	Business letter; style and tone	pp.550-554	
3	Letter of Inquiry	Notes pp.555-565	Letter of Inquiry
8	Letter of Complaint	pp.451-496	
10	Instructional Writing	Notes	
11	Answer-to-Inquiry Exercise		
15	Progress Reports	pp.214-224	Formal Report
17	Proposal Writing		
18	No class held		
	CHRISTMAS RECESS		
Jan.			
6	Oral Reporting		Letter of Complaint
7	Answer-to-Complaint Exercise		
8	Exercise		Letter of Application
12	Review		
13	FINAL EXAM.		

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